MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXII. FEBRUARY 14, 1902. NO. 4

Dr. J. W. L. Glaisher, M.A., F.R.S., President, in the Chair.

William Ambrose Kibbler, M.B., Ashby House, 3 Manor Road, Stamford Hill, N. ;
Charles F. Sandberg, M.A., Oxon, Lancing College, Shoreham, Sussex ;
Albert Walter, Royal Alfred Observatory, Mauritius ; and
Elward Fawcett White, Navigation Department, Merchant Venturers' Technical College, Bristol,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

George Herbert Bryant, Science Master, Hipperdale Schools, Cinderford, Gloucestershire (proposed by Albert Taylor) ;
Capt. G. P. Lenox-Conyngham, R.E., Survey of India, Mussoorie, India (proposed by Major E. H. Hills) ;
S. Alfred Mitchell, M.A. Ph.D., Tutor in Astronomy at Columbia University, New York City, U.S.A. (proposed by J. K. Rees) ;
James Rankine, 11 West Saville Road, Edinburgh (proposed by William Peck) ;
Thomas Thorp, Moss Bank, Whitefield, near Manchester (proposed by David G. Simpson) ; and
William Boultbee Whall, Younger Brother of the Trinity House, Nautical Surveyor, Board of Trade, Liverpool (proposed by M. J. O'Sullivan).

Report of the Council to the Eighty-Second Annual General Meeting of the Society.

The following table shows the progress and present state of the Society :—

	Compounders	Annual Subscribers	Total Fellows	Associates	Patron	Grand Total
1900 December 31	250	375	625	46	1	672
Since elected	+ 6	+22	...	+ 3	...	...
Deceased	− 6	− 7	...	− 3	...	...
Resigned	...	−11	...	...	...	...
Removals	...	...	...	...	...	...
Expelled	...	− 4	...	...	...	...
1901 December 31	250	375	625	46	1	672

Mr. Maw's Report as Treasurer of the Royal

RECEIPTS.

	£	s.	d.	£	s.	d.
Balances, 1901 January 1:—						
At Bankers', as per Pass-book	535	4	4			
Cheque not credited till 1901	4	4	0			
In hand of Assistant Secretary on Petty Cash Account	10	4	6			
				549	12	10
Dividends on £1,250 Metropolitan 3-per-cent. Stock	35	7	11			
Dividends on £932 19 0 Metropolitan 2½-per-cent. Stock	22	0	4			
Dividends on £3,400 East Indian Railway 3-per-cent. Debenture Stock	96	5	3			
Dividends on £3,200 London and North-Western Railway 3-per-cent. Debenture Stock	91	0	0			
Half-year's Dividend on £3,600 Midland Railway 2½-per-cent. Debenture Stock	42	15	0			
Half-year's Dividend on £4,000 Midland Railway 2½-per-cent. Debenture Stock	47	5	10			
Dividends on £1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock	52	17	10			
Dividends on £1,100 Commercial Gas Co. 4½-per-cent. Debenture Stock	46	14	3			
Interest on £300 on Deposit at Bankers'	3	0	7			
				437	7	0
Received on account of Subscriptions:—						
Arrears	165	18	0			
Annual Contributions for 1901	613	4	0			
„ „ 1902	6	6	0			
Admission Fees	63	0	0			
First Contributions	35	14	0			
				884	2	0
Composition Fees				126	0	0
Sales of Publications:—						
At Williams and Norgate's, 1900	11	5	7			
At Society's Rooms, 1901	73	10	3			
Sales of Photographs, 1901	28	9	6			
				113	5	4
Income Tax refunded by Commissioners of Inland Revenue				21	8	9
Cheques outstanding 1901 December 31				16	19	6
Due to Assistant Secretary on Petty Cash Account				1	19	3
				£2,150	14	8

Examined and found correct, 1902 Jan. 8:
W. B. Gibbs, H. P. Hollis, F. W. Levander.

Astronomical Society, from 1901 *January* 1 *to December* 31.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
„ „ for assistance in editing Society's Publications ...	50	0	0			
				300	0	0
House Duty	2	12	6			
Fire Insurance	9	9	6			
				12	2	0
Printing *Monthly Notices*	459	12	8			
„ Appendix to *Monthly Notices*	30	3	0			
„ „ *Memoirs*	14	16	0			
„ Supplementary Library Catalogue ...	64	18	9			
„ List of Fellows, Charter and Bye-Laws, and Miscellaneous	23	19	0			
				593	3	5
Computation of Ephemerides in *Monthly Notices* ...				15	0	0
Turnor and Horrox Funds: Purchases for Library	21	9	10			
Folios and mounts for drawings in Library ...	6	2	6			
				27	12	4
Reproduction of Photographs				21	12	8
Cataloguing astronomical literature for the International Catalogue of Scientific Literature ...				30	0	0
Clerk's Wages	52	0	0			
Postage and Telegrams	84	8	3			
Carriage of Parcels, &c.	3	5	2			
Stationery (Spottiswoode & Co.)	4	4	6			
Sundry Stationery and Office Expenses	3	7	4			
				147	5	3
Expenses of Meetings	20	0	0			
Lantern Expenses	10	15	0			
Time Signal, &c.	6	10	0			
				37	5	0
House Expenses	67	1	10			
Coals and Gas	53	18	11			
Electric Light Expenses	9	13	4			
Furniture, Repairs, &c.	9	13	10			
Sundry Fittings and Repairs	9	18	11			
Sundries	7	1	5			
				157	8	3
Illuminating Address to His Majesty	5	13	0			
Gold Medals	52	10	0			
				58	3	0
Purchase of £400 Midland Railway 2½-per-cent. Debenture Stock				340	12	6
Cheque-book and deductions on Cheques					11	9
Repayment to Assistant Secretary of amount due 1901 Jan. 1 on account of Turnor and Horrox Funds				2	0	11
Balances, 1901 December 31:—						
At Bankers', as per Pass-book	101	8	4			
„ „ on deposit	300	0	0			
In hand of Assistant Secretary on account of Turnor and Horrox Funds	6	9	3			
				407	17	7
				£2,150	14	8

Report of the Auditors.

We have examined the Treasurer's accounts of receipts and expenditure for the year 1901, and have found and certified the same to be correct. The cash in hand on December 31, 1901, including the balance at the bankers', &c., amounted to £407 17*s.* 7*d.*

During the past year the sum of £340 12*s.* 6*d.* has been invested in the purchase of £400 Midland Railway 2½ per cent. Debenture Stock.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

We wish to call the attention of the Society to the fact that there are now 250 compounding Fellows out of a total number of 625 ; and that in our opinion it would be conducive to the interests of the Society that the composition fee should be increased.

(Signed) W. B. Gibbs,
H. P. Hollis,
F. W. Levander.

Trust Funds.

The Turnor Fund: A sum of £464 18*s.* East Indian Railway 3-per-cent. Debenture Stock ; the interest to be used in the purchase of books for the Library.

The Horrox Memorial Fund: A sum of £103 6*s.* East Indian Railway 3-per-cent. Debenture Stock ; the interest to be used in the purchase of books for the Library.

The Lee and Janson Fund: A sum of £334 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock ; the interest to be given by the Council to the widow or orphan of any deceased Fellow of the Society who may stand in need of it.

The Hannah Jackson (née Gwilt) Fund : A sum of £309 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock ; the interest to be given in Medals or other awards, in accordance with the terms of the Trust.

Assets and Present Property of the Society, 1902 January 1.

	£	s.	d.	£	s.	d.
Balances, 1901 December 31:—						
At Bankers', as per Pass-book	101	8	4			
„ „ on deposit	300	0	0			
In hand of Assistant Secretary on account of Turnor and Horrox Funds	6	9	3			
	407	17	7			
Less due to Assistant Secretary on Petty Cash Account £1 19 3						
Less due to Cheques outstanding 16 19 6						
	18	18	9			
				388	18	10
Due on account of Subscriptions:—						
1 Contribution of 5 years' standing	10	10	0			
2 Contributions of 4 „	16	16	0			
10 „ 3 „	63	0	0			
18 „ 2 „	75	12	0			
61 „ 1 year's standing	128	2	0			
	294	0	0			
Less 3 Contributions paid in advance ...	16	6	0			
				287	14	0
Due from Williams and Norgate for sales of Publications during 1901				13	16	4
£3,400 East Indian Railway 3-per-cent. Debenture Stock, including the Turnor Fund, the Horrox Memorial Fund, the Lee and Janson Fund, and the Hannah Jackson (née Gwilt) Fund.						
£3,200 London and North Western Railway 3-per-cent. Debenture Stock.						
£4,000 Midland Railway 2½-per-cent. Debenture Stock.						
£1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock.						
£1,100 Commercial Gas Company 4½-per-cent. Debenture Stock.						
£1,250 Metropolitan 3-per-cent. Stock.						
£932 19 0 Metropolitan 2½-per-cent. Stock.						
Astronomical and other Manuscripts, Books, Prints, and Instruments.						
Furniture, &c.						
Stock of Publications of the Society.						
Five Gold Medals.						

Stock in hand of volumes of the *Memoirs*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	8	...	XXXII.	145	...
I. Part 2	42	...	XXXIII.	154	...
II. Part 1	51	3	XXXIV.	156	...
II. Part 2	16	3	XXXV.	104	1
III. Part 1	65	1	XXXVI.	187	8
III. Part 2	82	1	XXXVII. Part 1	330	7
IV. Part 1	77	3	XXXVII. Part 2	278	8
IV. Part 2	89	3	XXXVIII.	263	1
V.	100	3	XXXIX. Part 1	228	2
VI.	117	6	XXXIX. Part 2	233	2
VII.	140	3	XL.	248	...
VIII.	124	3	XLI.	392	1
IX.	130	3	XLII.	224	3
X.	142	...	XLIII.	221	...
XI.	147	...	XLIV.	205	1
XII.	152	...	XLV.	238	...
XIII.	150	...	XLVI.	214	2
XIV.	358	...	XLVII. Part 1	2	...
XV.	131	...	XLVII. Part 2	18	...
XVI.	157	1	XLVII. Part 3	2	...
XVII.	140	1	XLVII. Part 4	8	...
XVIII.	132	1	XLVII. Part 5	8	...
XIX.	143	...	XLVII. Part 6	9	...
XX.	133	1	XLVII.	194	1
XXI. Part 1	244	...	XLVIII. Pt. 1	226	1
XXI. Part 2	98	...	XLVIII. Pt. 2	227	1
XXI.	54	...	XLIX. Part 1	352	...
XXII.	156	...	XLIX. Part 2	236	2
XXIII.	141	...	L.	226	2
XXIV.	147	1	LI.	257	...
XXV.	153	...	LII.	307	...
XXVI.	163	1	LIII.	322	1
XXVII.	417	1	LIV. App. I.	716	...
XXVIII.	371	...	App. II.	745	...
XXIX.	395	1	Index to *Memoirs*	619	2
XXX.	147	1			
XXXI.	134	...			

Stock in hand of volumes of the *Monthly Notices*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	53	...	XXXIII.	86	...
II.	55	...	XXXIV.	65	1
III.	...	...	XXXV.	51	...
IV.	...	...	XXXVI.	25	1
V.	...	...	XXXVII.	31	3
VI.	40	...	XXXVIII.	95	1
VII.	2	...	XXXIX.	95	...
VIII.	151	2	XL.	103	3
IX.	23	3	XLI.	103	5
X.	170	1	XLII.	111	1
XI.	181	...	XLIII.	108	2
XII.	104	1	XLIV.	110	2
XIII.	176	2	XLV.	114	1
XIV.	175	3	XLVI.	107	...
XV.	167	2	XLVII.	122	2
XVI.	152	1	XLVIII.	117	...
XVII.	164	...	XLIX.	108	7
XVIII.	242	...	L.	108	9
XIX.	51	...	LI.	110	6
XX.	31	...	LII.	107	10
XXI.	16	...	LIII.	111	13
XXII.	30	...	LIV.	109	13
XXIII.	17	...	LV.	122	...
XXIV.	22	...	LVI.	120	2
XXV.	13	...	LVII.	127	2
XXVI.	9	...	LVIII.	124	...
XXVII.	3	...	LIX.	129	3
XXVIII.	70	...	LX.	133	4
XXIX.	50	...	LXI.	150	...
XXX.	61	2	1st Index ...	541	1
XXXI.	90	...	2nd ,, ...	796	...
XXXII.	106	5			

Library Catalogue	540	2
,, ,, Supplement	422	...

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly

all the volumes. With the exception, however, of Vols. XXXVI. to LXI., no complete volumes can be formed from the separate numbers in stock.

Celestial Photographs.

The following is a list of reproductions of Celestial Photographs published by the Royal Astronomical Society for sale to the Fellows :—

R.A.S. Ref. No.	Subject.	Photographed by
1	Total Solar Eclipse, 1889 January 1	W. H. Pickering
2	Total Solar Eclipse, 1893 April 16	J. M. Schaeberle
3	Total Solar Eclipse, 1886 August 29	A. Schuster
4	Nebulæ in the *Pleiades*	Isaac Roberts
5	Nebula M 74 *Piscium*	Isaac Roberts
6	Great Nebula in *Orion*	Isaac Roberts
7	Milky Way near M 11	E. E. Barnard
8	Milky Way near Cluster in *Perseus*	E. E. Barnard
9	Comet *c* 1893 IV. (Brooks), 1893 October 21	E. E. Barnard
10	Comet *a* 1892 I. (Swift), 1892 April 7	E. E. Barnard
11	Nebula about η *Argûs*	David Gill
12	Portion of Moon (Hyginus-Albategnius)	Lœwy and Puiseux
13	Comet *c* 1893 IV. (Brooks), 1893 October 22	E. E. Barnard
14	Comet *c* 1893 IV. (Brooks), 1893 October 20	E. E. Barnard
15	Comet *c* 1893 IV. (Brooks), 1893 November 10	E. E. Barnard
16	Comet *a* 1892 I. (Swift), 1892 April 26	E. E. Barnard
17	Comet *f* 1892 III. (Holmes), 1892 November 10	E. E. Barnard
18	Comet *a* 1892 I. (Swift), 1892 April 18	E. E. Barnard
19	Portion of Moon (Alps, Apennines, &c.)	Lœwy and Puiseux
20	Nebula in *Andromeda*	Isaac Roberts
21	*Jupiter*, 1892 September 26	Lick Observatory
22	Cluster M 13 *Herculis*	W. E. Wilson
23	Total Solar Eclipse, 1893 April 16 (5 sec.)	J. Kearney
24	Total Solar Eclipse, 1893 April 16 (20 sec.)	J. Kearney
25	The Moon (Age $7^d\ 3^h$)	Lick Observatory
26	The Moon (Age $12^d\ 6\frac{1}{2}^h$)	Lick Observatory
27	The Moon (Age $16^d\ 18^h$)	Lick Observatory
28	The Moon (Age $23^d\ 8^h$)	Lick Observatory

R.A.S. Ref. No.	Subject.	Photographed by
29	The Sun, 1892 February 13	Roy. Obs., Greenwich
30	The Sun, 1892 July 8	Roy. Obs., Greenwich
31	Portion of Moon (Region of Maginus)	Lœwy and Puiseux
32	The Moon (Age 14^d 1^h)	Lick Observatory
33	Portion of Moon (Ptolemæus, &c.)	Lick Observatory
34	Portion of Moon (Mare Serenitatis)	Lick Observatory
35	Portion of Moon (Clavius, Licetus, &c.)	Lick Observatory
36	Portion of Moon (Regiomontanus, &c.)	Lick Observatory
37	Portion of Moon (Tycho, Thebit, &c.)	Lick Observatory
38	Portion of Moon (Theophilus, &c.)	Lick Observatory
39	Total Solar Eclipse, 1896 August 9 (3 sec.)	S. Kostinsky
40	Total Solar Eclipse, 1896 August 9 (26 sec.)	A. Hansky
41	Cluster M 56 *Lyræ*	
42	Nebulæ M 81, 82 *Ursæ Majoris*	
43	Cluster M 56 *Lyræ* (enlarged)	
44	Solar Corona, 1871 December 12, Baikul	H. Davis
45	Solar Corona, 1875 April 6, Siam	Lockyer and Schuster
46	Solar Corona, 1878 July 29, Wyoming	W. Harkness
47	Solar Corona, 1882 May 17, Egypt	Abney and Schuster
48	Solar Corona, 1883 May 6, Caroline Island	Lawrance and Woods
49	Solar Corona, 1885 September 9, Wellington, N.Z.	Radford
50	Solar Corona, 1886 August 29, Grenada, W.I.	A. Schuster
51	Solar Corona, 1887 August 19, Japan	M. Sugiyama
52	Solar Corona, 1889 January 1, California	W. H. Pickering
53	Solar Corona, 1889 December 22, Cayenne	J. M. Schaeberle
54	Solar Corona, 1893 April 16, Fundium	J. Kearney
55	Solar Corona, 1893 April 16, Brazil	A. Taylor
56	Great Nebula in *Orion*	W. E. Wilson
57	Dumb-bell Nebula, *Vulpecula*	W. E. Wilson
58	Spiral Nebula, *Canes Venatici*	W. E. Wilson
59	Spiral Nebula, *Canes Venatici* (enlarged)	W. E. Wilson
60	Annular Nebula, *Lyra*	W. E. Wilson
61	Meteor Trail and Comet Brooks, 1893 November 13	E. E. Barnard
62	Total Solar Eclipse, 1898 January 22 (5 sec.)	W. H. M. Christie
63	Total Solar Eclipse, 1898 January 22 (20 sec.)	W. H. M. Christie
64	Solar Corona, 1896 August 9, Novaya Zemlya	G. Baden-Powell
65	Solar Corona, 1898 January 22, Pulgaon, India	E. H. Hills
66	Nebula in *Andromeda*	Roy. Obs., Greenwich
67	Spectrum of Sun's limb, 1898 January 22	E. H. Hills

R.A.S. Ref. No.	Subject.	Photographed by
68	Annular Nebula, *Lyra*	Lick Observatory
69	Dumb-bell Nebula, *Vulpecula*	Lick Observatory
70	Spiral Nebula, *Canes Venatici*	Lick Observatory
71	Spiral Nebula, *Ursa Major*	Lick Observatory
72	Trifid Nebula, *Sagittarius*	Lick Observatory
73	Great Nebula in *Orion*	Lick Observatory
74	Cluster M 13 *Herculis*	Lick Observatory
75	Solar Surface with Faculæ	G. E. Hale
76	Faculæ and Prominences	G. E. Hale
77	Total Solar Eclipse, 1898 Jan. 22 ($\frac{2}{3}$ sec.)	W. H. M. Christie
78	Nebula H V. 14 *Cygni*	W. E. Wilson
79	Portion of Moon (Theophilus, &c.)	Yerkes Observatory
80	Total Solar Eclipse, 1900 May 28 (30 sec.)	E. E. Barnard
81	Comet 1901 I., 1901 May 4	Roy. Obs., Cape of G. H.
82	Comet 1901 I., 1901 May 6	Roy. Obs., Cape of G. H.
83	Comet 1901 I., 1901 May 9	Perth Obs., W. Australia
84	Solar Surface with Faculæ	H. Deslandres
85	Solar Prominences	H. Deslandres

Nos. 44–55 and Nos. 64 and 65 form a series of corona photographs, oriented and reduced to the same scale.

The above photographs are now on sale to Fellows as prints, either platinotype or aristotype, mounted on sunk cut-out mounts, measuring 12 inches by 10 inches, and also as lantern slides. Nos. 44–55 and Nos. 64 and 65 are also supplied as transparencies, $6\frac{1}{4}$ inches square.

Price of prints, 1*s.* 6*d.* each; lantern slides, 1*s.* each; packing and postage extra.

Unmounted prints, 1*s.* each, can be obtained to order.

Transparencies, $6\frac{1}{4}$ inches square (Nos. 44–55 and Nos. 64 and 65), 3*s.* 6*d.* each.

Orders to be addressed to W. H. Wesley, Burlington House, London, W. In ordering prints or slides the R.A.S. Reference No. only need be quoted, but in the case of prints it should be stated whether platinotypes or aristotypes are required.

Instruments belonging to the Society.

A brief description of the chief instruments and other particulars relating to them will be found in *Monthly Notices*, vol. xxxvi. p. 126.

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.
„ 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.
„ 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.
„ 7. The *Smeaton* equatorial.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatorial.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatorial, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.

The *Sheepshanks* collection :—

„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumb-line; portable clamping foot and tripod stand.
„ 29. (3) Equatorial stand and clock movement for $4\frac{6}{10}$-inch telescope (telescope lost); double-image micrometer; two wire micrometers; object-glass micrometer.
„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

No. 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

„ 33. (7) 2-foot navy telescope.

„ 34. (8) Transit instrument of 45 inches focal length, with iron stand and also Y's for fixing to stone piers; two axis levels.

„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

„ 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, reading to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end, reading to single minutes; horizontal circle 9 inches diameter in brass to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y-piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator, with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon, with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

No. 47. (21) Box sextant ; reflecting plane and level.
„ 48. (22) Prismatic compass, by Troughton and Simms.
„ 49. (23) Mountain barometer.
„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.
„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.
„ 52. (26) Dipping needle, by Robinson.
„ 53. (27) Compass needle, mounted for variation.
„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen ; a strongly fitted brass box with heavy magnet ; filar suspension.
„ 55. (29) Box of magnetic apparatus.
„ 56. (30) Hassler's reflecting circle, by Troughton ; a $10\frac{1}{2}$-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices ; four verniers reading to 10″.
„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.
„ 58. (32) Plane $2\frac{3}{8}$-inch speculum, artificial horizon and stand.
„ 59. (33) $2\frac{1}{2}$-inch circular level horizon, by Dollond.
„ 60. (34) Artificial horizon, roof, and trough ; the trough $8\frac{1}{4}$ by $4\frac{1}{2}$ inches ; tripod stand.
„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square ; one beam compass.
„ 62. (36) A pantograph.
„ 63. (37) A noddy.
„ 64. (38) A small Galilean telescope with object-glass of rock crystal.
„ 65. (39) Five levels.
„ 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with object-glass of rock crystal.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. $9\frac{1}{4}$-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms ; two Babinet's compensators ; two double-image prisms ; three Savarts ; one positive eyepiece, with Nicol's prism ; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.
„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.
„ 84. A Hollis observing chair.
„ 85. Double-image micrometer, by Troughton and Simms.

No. 86. $4\frac{1}{2}$-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.
„ 87. $3\frac{1}{4}$-inch Gregorian reflecting telescope with wooden tripod stand.
„ 88. Pendulum, with 5-foot brass suspension rod, working on knife-edges, by Thomas Jones.
„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.
„ 90. An Arabic celestial globe of bronze, $5\frac{3}{4}$ inches in diameter.
„ 91. Astronomical time watch-case, by Professor Chevallier.
„ 92. 2-foot protractor, with two movable arms, and vernier.
„ 93. Beam compass, in box.
„ 94. 2-foot navigation scale.
„ 95. Stand for testing measures of length.
„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position angles.
„ 97. 12-cell Leclanché battery.
„ 98. 2-foot 6-inch navy telescope, with object-glass $2\frac{1}{2}$ inches, by Cooke, with portable wooden tripod stand.
„ 99. 12-inch transit instrument, by Fayrer and Son, with level and portable stand.
„ 100. 9-inch transit instrument, with level and iron stand.
„ 101. Small equatorial sight instrument, by G. Adams, London.
„ 102. Sun-dial, by Troughton.
„ 103. Sun-dial, by Casella.
„ 104. Sun-dial.
„ 105. Box sextant, by Troughton and Simms.
„ 106. Prismatic compass, by Schmalcalder, London.
„ 107. Compass, by C. Earle, Melbourne.
„ 108. Prismatic compass, by Negretti and Zambra.
„ 109. Dipleidoscope, by E. Dent.
„ 110. Abney level, by Elliott.
„ 111. Pocket spectroscope, by Browning.
„ 112. Universal sun-dial.
„ 113. Double sextant, by Jones.
„ 114. Two models, illustrating the effects of circular motions.
„ 115. A cometarium.
„ 117. Two old sun-dials.
„ 118. A $10\frac{1}{2}$-inch sixteenth-century celestial globe, on bronze tripod stand.
„ 119. Specimens of diffraction gratings, by Prof. W. A. Rogers.
„ 120. A 6-prism spectroscope, by Browning.
„ 121. Spitta's improved maximum and minimum thermometer.

No. 122. A 6-inch speculum, with flat; the speculum said to be by Sir W. Herschel, and re-figured by Sir J. Herschel.
„ 123. A 6-inch refracting telescope, by Grubb, with 3 eyepieces.
„ 124. Position micrometer, by Cooke.
„ 125. A 6-inch refracting telescope, by Simms, with eyepieces and solar diagonal.
„ 126. $3\frac{1}{2}$-inch portable refracting telescope, by Tulley, with tripod stand.
„ 127. Globe representing the visible surface of the Moon, by John Russell, R.A. (1797).
„ 128. Bichromate battery and Ruhmkorff coil.
„ 129. Slater's improved armillary sphere.
„ 130. 10-inch brass pillar sextant with counterpoise stand, by Troughton.
„ 131. Double box sextant, by Cary.
„ 132. Equatorially mounted camera with $2\frac{1}{2}$-inch portrait lens and telephotographic enlarging lens by Dallmeyer; iron pillar.
„ 133. $3\frac{1}{4}$-inch equatorial by Ross, with tall tripod stand, equatorial mounting, eyepieces, and micrometer.
„ 134. Old transit instrument, 2-inch aperture and 3 feet focal length (without stand), formerly belonging to Dr. Longfield, of Cork.
„ 135. Globe of Mars, by E. M. Antoniadi.
„ 136. A small universal instrument by W. and S. Jones, London; the telescope $1\frac{1}{2}$-inch aperture and 15 inches focal length. [Presented by Miss Moore.]
„ 137. Polar siderostat by Hilger, with $4\frac{1}{8}$-inch mirrors. [Presented by Mr. Alexr. Foote.]
„ 138. Transit instrument, aperture $2\frac{3}{4}$-inch, with collimator and stand. [Presented by Mrs. Cross.]
„ 139. Transit instrument, aperture $1\frac{11}{12}$-inch, with portable stand. [Presented by Mrs. Cross.]
„ 140. $3\frac{3}{4}$-inch object-glass and tube. [Presented by Mrs. Cross.]

Besides the above, there is the following apparatus available for eclipse work :—

4 Slits for spectroscope.
Abney doublet lens used in photographing the corona.
2 Dallmeyer negative enlarging lenses.
Cœlostat with 16-inch plane mirror.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons :—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.

No. 22. The *Matthew* equatorial, to Mr. C. Thwaites.
„ 23. The *Matthew* transit, to Captain W. Noble.
„ 28. (2) 6-inch theodolite and stand, to Dr. A. A. Common.
„ 29. (3) Equatorial mounting, clock, &c., to the Rev. C. D. P. Davies.
„ „ Wire micrometer (No. 2), to the Rev. C. D. P. Davies.
„ 30. (4) $3\frac{1}{4}$-inch equatorial and stand, to Mr. C. H. Johns.
„ „ Double-image micrometer, to the Rev. W. J. B. Roome.
„ 57. (31) Box sextant, to Dr. A. A. Common.
„ 69. (43) Telescope with rock-crystal object-glass, to Sir W. Huggins.
„ 72. (*c*) Polarimeter, to Professor C. Michie Smith.
„ 78. $9\frac{1}{4}$-inch reflector and stand, to the Rev. W. J. B. Roome.
„ 80. Box of polariscopic apparatus, to Mr. H. F. Newall.
„ 98. 2-foot 6-inch navy telescope, to the Rev. J. M. Bacon.
„ 123. 6-inch telescope, by Grubb (object-glass only), to Mr. W. E. Wilson.
„ 125. 6-inch refractor, by Simms, to Dr. A. A. Common.
„ 133. $3\frac{1}{4}$-inch equatorial, by Ross, to Dr. A. W. Roberts.

Award of Medals.

The Council have awarded the Society's Gold Medal to Professor J. C. Kapteyn, for his work in connection with the Cape Photographic Durchmusterung, and his researches on stellar distribution and parallax. The President will lay before the Society the grounds upon which the award has been founded.

The Hannah Jackson (née Gwilt) Gift and Bronze Medal have been awarded to the Rev. Thomas D. Anderson for his discovery of *Nova Aurigæ* and *Nova Persei*.

Reprinting of Astronomical Papers from the Publications of the Royal Society.

By the courtesy of the Royal Society permission has been granted to the Council of the Royal Astronomical Society to issue to the Fellows, in the form of Appendices to the *Memoirs* and *Monthly Notices*, papers of astronomical interest which appear in the *Philosophical Transactions* and *Proceedings* of the

Royal Society. The Council of the Royal Society have also further kindly arranged that notice be sent to the Royal Astronomical Society as soon as papers which might be required are in type, so that the additional copies for the Appendices to the *Memoirs* or *Monthly Notices* can be obtained before the type is distributed, the Royal Astronomical Society paying for the cost of striking off the additional copies.

During the past year four numbers of Appendix to vol. lxi. of the *Monthly Notices* have been published, containing, amongst others, a series of papers on *Nova Persei*, by Sir Norman Lockyer; and one Appendix to vol. lxii., containing the preliminary reports of the observers of the total solar eclipse of 1901.

The following Appendices to vol. liv. of the *Memoirs* have also been issued:

I. Sir Norman Lockyer, Total eclipse of the Sun, 1898 January 22; observations at Viziadrug.

II. J. Evershed, Wave-length determinations and general results obtained from a detailed examination of spectra photographed at the solar eclipse of 1898 January 22.

Address to His Majesty.

The Council have pleasure in announcing that His Majesty King Edward VII. was graciously pleased to accept the Address of condolence and homage, the text of which was printed on p. 181 of last year's Annual Report. The Address was presented by the President and Secretary, and was received by His Majesty in person at St. James's Palace on March 20, 1901.

On April 18 a letter was received by the President from General Sir D. Probyn, Keeper of H.M. Privy Purse, announcing that His Majesty had graciously consented to become the Patron of the Society.

Obituary.

The Council regret that they have to record the loss by death of the Society's gracious Patron Her late Majesty Queen Victoria and of the following Fellows and Associates during the past year :—

Fellows :—Rev. J. Chadwick Bates.
E. E. Bowen.
*John Brett.
Rev. R. Crowe.
Major-Gen. A. W. Drayson.
J. P. Hartree.
Lord Inverclyde.
S. Wellesley Johnson.
William Lethbridge.
†D. L. Lowson.
Charles Meldrum.
John Parnell.
Sir Cuthbert E. Peek.
B. Woodd Smith.
Associates :—H. A. Rowland.
T. H. Safford.
Wilhelm Schur.

J. Chadwick Bates was born on the 17th of June 1826 at Oldham. He was educated at Manchester Grammar School and Queen's College, Oxford. He was ordained by the Bishop of Manchester in 1850. From 1851 to 1856 he had a curacy at Hull, and for the last 43 years his life was closely interwoven with the history of the village of Castleton, of which he was vicar. His first interests were in the welfare of his church, schools, and the public affairs of his parish. When he went to Castleton it was a small village, and he was appointed curate in charge of a small mission chapel by the Vicar of Rochdale. He soon started a movement towards building a church, and by 1862 St. Martin's Church had been built at a cost of 3,000*l.* During the 43 years Mr. Bates was Vicar of Castleton no less than 16,000*l.* was raised for parochial objects.

* Although Mr. Brett died subsequently to December 31, 1901, an account of his life is given in this year's Report.

† Removed from List as deceased, his name having been in the List of Fellows without address for eighteen years.

Mr. Bates took a deep interest in several branches of science, particularly astronomy, meteorology, and geology. He had a well-equipped meteorological station in the vicarage garden and kept a careful record of the rainfall, temperature, &c. He was a Fellow of the Geological Society as well as of the Royal Astronomical Society, to which he was elected on the 13th of November 1863. Mr. Bates possessed considerable mechanical skill, and constructed almost entirely with his own hand the dome over his equatorial. He built a room for his transit instrument himself, and he also carved parts of the stonework of the church.

Mr. Bates married a Miss Jackson, of Hull, who died in 1874. They had one son and four daughters. He died on the 14th of December 1901, at St. Martin's Vicarage after a short illness.

Edward Ernest Bowen was born in 1836, being the second son of the Rev. Christopher Bowen, sometime Vicar of St. Thomas's, Winchester; his elder brother was the late Lord Bowen, the well-known Judge. Edward Bowen went up from King's College, London, to Trinity College, Cambridge, in 1854; he was a Bell Scholar for 1855. In 1858 he was fourth in the Classical Tripos, and shortly afterwards obtained a Fellowship at Trinity. He left Cambridge soon after to become a master at Harrow, where the rest of his life was spent unreservedly and whole-heartedly for the welfare of the school and in the service of his pupils. His brilliant intellect, sound judgment, and unlimited kindness made him an ideal schoolmaster.

Many who have never seen him have been charmed by his school songs. "Forty Years On" has long been classical, and is known far beyond the bounds of Harrow.

A typical Bowenite institution at Harrow was "astronomy." Every boy in his house had to attend two courses of lectures before he left—one astronomy, the other the history of a war—but both were called by the boys "astronomy." Each Christmas term, for one evening in every week, the astronomers (roughly speaking, the middle-sized boys of the house) were gathered in his drawing room, and, if it was astronomy proper, he explained the courses of the heavens by aid of a little round table that was the Sun, a cricket-ball that was the Moon, putting them through their various motions in the centre of the room. Sometimes he himself actively personified the Moon or some other heavenly body, while the boys sat round critically spectatorial. The boys had no function but to look on, but evil waited on him who did not understand and remember.

Mr. Bowen died on the 8th of April at Moux, in the Côte-d'Or, France, while on a bicycling tour. He was to all appearance in perfect health, but fell while mounting his machine and never recovered consciousness.

He was elected a Fellow of the Astronomical Society on the 8th of February 1867.

JOHN BRETT was born at Reigate on the 8th of December 1831. He was an artist of eminence, and was elected an Associate of the Royal Academy in 1881. "In early life" (to quote the *Times* of the 9th of January) "he came strongly under the influence of the Pre-Raphaelite movement. Over an early picture of his, *The Stonebreaker*, Ruskin grew enthusiastic. 'It is a marvellous picture,' he wrote, 'and may be examined inch by inch with delight;' and again, 'I know no such thistle-down, no such chalk hills and elm trees, no such natural pieces of far-away cloud.' This picture was exhibited at the Royal Academy in 1858. In the following year Brett showed his famous *Val d'Aosta*, in which he endeavoured, not without success, to carry out the principles of the pre-Raphaelites in landscape-painting. Very few artists have tried to do this, though Holman Hunt, in addition to Brett, showed that the aims of the school could be illustrated by landscape as well as by romantic figure pictures." Perhaps the most famous of the many pictures of sea and coast scenery which he painted later was his *Britannia's Realm*, a simple stretch of open sea, which nevertheless fascinated the attention; it was exhibited at the Royal Academy in 1880, and purchased by the Trustees of the Chantrey Bequest. He continued to paint and exhibit up to the closing years of his life, and died at the ripe age of 70 on the 7th of January 1902.

Mr. Brett was a devoted astronomer throughout his life. "I think he was about thirteen or fourteen years old," writes his brother, "when he *bought* his first telescope, and that was a 3-inch reflector. I remember it well. Before that time he had always made up his telescopes of such pieces as he could collect at second-hand shops. From the 3-inch reflector he went to a 6-inch; and when he was sixteen, or perhaps seventeen, he made his 9-inch telescope, casting its speculum in the disused coach-house at home, and grinding it and polishing it on a machine in his painting-room. Many a halfpenny I earned turning the handle. He was well convinced of the disadvantages appertaining to any tubular connection between the speculum and the eye-piece; and that 9-inch reflector had no tube, the connection being by a stout beam or bar of wood at one side; and in his last 11-inch Browning reflector the same principle is carried out. Currents of air and needless vibrations are thus avoided."

Mr. Brett was elected a Fellow of this Society on the 9th of June 1871. Just previously he had been out to Sicily with the expeditions to observe the total solar eclipse of the 21st of December 1870, and had made observations, of which he gave a clear account (*Monthly Notices*, xxxi., p. 163) and several drawings. He states what he saw with an independence and fearlessness which his subsequent papers showed to be characteristic. "The appearance (near the limb), on the whole, was far more like terrestrial conflagration than I expected, especially (in a footnote) the combustion of wood in a baker's oven when nearly exhausted.

. . . . I must confess I was extremely vexed not to see anything like the corona I expected ; I should never have called this a corona at all. . . . . There were certainly no streamers, so I conclude they must have been intercepted by the cloud. I do not mean merely that their light was, but their cause also. . . . . I conclude that the dew which would have formed streamers was, at Augusta, intercepted or prevented by cloud ; although the latter was not dense enough to conceal much." (*Monthly Notices*, xxxi., pp. 165–6.) We now know that this conclusion as to the terrestrial nature of the streamers was incorrect ; but Mr. Brett, no doubt, recorded very faithfully what he saw. His trained eye was a most effective astronomical weapon, and his actual observations are deserving of every respect, though when he proceeded to draw deductions he is more open to criticism.

At this same eclipse he noticed a "ray or cone of light emanating from the south (later, also the north) cusp in a direction tangential to the Moon's limb, length not more than 3′ : light less intense than that of the cusp, but as beautifully defined as anything I ever saw in my life." At the partial eclipse on the 10th of October 1874 he saw the same phenomenon on a much smaller scale, and made the suggestion of a lunar atmosphere, which is only of appreciable density in the deepest valleys. This is not the place to discuss the conclusion, but the observations are well worthy of note ; as also those from which Mr. Brett concluded that indications of the corona could be seen without an eclipse (*Monthly Notices*, xxxii., 297).

His other observations (made at his residence at Putney, chiefly with the Browning reflector above mentioned, for which he devised a simple but firm altazimuth mounting, though he had, also, the Matthew Equatorial on loan from this Society for many years) were of planetary detail, and called attention to several points of great importance. He observed that the white spots on *Jupiter* were either themselves shaded or cast a shadow, and concluded that "neither the dark belts nor the bright ones are opaque, and that if *Jupiter* has any nucleus at all it is not visible to us." He observed that the brightest point of the disc of *Venus* was not at the limb, but sensibly within the limb, indicating that there was specular reflection from its surface largely modified by atmospheric diffusion. And, finally, he observed shadows cast by the polar caps of *Mars*, and concluded that they were not snow, but cloud.

These observations met with almost a storm of incredulity in some quarters when communicated to the Society. "One is tempted to ask," wrote the late Mr. R. A. Proctor to the *Astronomical Register* (vol. xv., page 45), "what is coming to the Royal Astronomical Society when such a paper as Mr. Brett's, on the bright ring seen round *Venus* during transit, is allowed by the Council to be read before a meeting of the Fellows ? . . . All that the spectroscope has taught us, all that we have learned of meteoric and cometic systems and of the laws of cosmical

evolution, the laws of optics, and in fine the teachings of every department of modern astronomy, seem of no weight whatever with the excellent artist whose paintings of Scilly scenery delighted us so much a year or so since. Not content with seeing the corona in the full blaze of sunlight, and setting globes as large as the Earth bobbing in the atmosphere of *Jupiter*, he would now set astronomers to look during the transit of *Venus* in 1882 for an image of the Earth reflected in *Venus's* looking-glass! What next? and next?" They were times when views were expressed with considerable frankness within the Society; and Mr. Brett himself, it may be acknowledged, was one of those who spoke his mind most directly. But those who, instead of ridiculing an observation because it announced a new fact, took the trouble to test it by observation themselves, generally found that Mr. Brett's keen sight had not misled him. The present Astronomer Royal tested the announcement of specular reflection from *Venus* by an independent method with the 13-inch Merz refractor, and verified it; and he followed Mr. Brett in his explanation of the bright ring seen round *Venus* in transit as due to specular reflection modified by atmospheric diffusion. The observations on *Mars* have been corroborated, though differently interpreted; for other observers have seen a dark border to the caps and called it melted snow. The shadows cast by white spots on *Jupiter* were confirmed by M. Faye in a paper read to the French Academy in 1876; and, as regards seeing the corona in daylight, M. Tacchini recorded an even more remarkable observation in 1879 (*Observatory*, vol. ii., page 423). Recently more attention has been paid to the photography of the corona without an eclipse than to eye observation of it. If in the future our attention is recalled to eye observations, Mr. Brett may again be found to be right. His own generation, though his observations came as a shock to them, were not lacking in recognition of his merits. He was elected on the Council in 1876 and again in 1877. As a "sign of the times," it may be recalled that the scrutineers were only able to announce the Council list in 1877 after an absence of two hours and a half. Mr. Brett was constantly at the meetings of the Society until the last ten years, when his failing health prevented attendance; and his characteristically emphatic remarks were a well-known element in the discussions. Almost his last appearance was in April 1892, when Captain (now Sir William) Abney read a paper on the extinction of star-light with a wedge, and talked of the fatigue caused by looking at different colours, saying that looking at red for some time rendered the red nerves useless. "You can look at the green till all is blue, sir!" interjected Mr. Brett, and Captain Abney at once acknowledged the aptness of the remark.

In his paintings Mr. Brett found greater scope for exact appreciation of meteorological than of astronomical phenomena; but in one of his great pictures, "Summer Sunset in the Hebrides,"

painted in 1880, he shows how the Sun may be painted the right size (usually it is grossly exaggerated in pictures) and yet produce the right effect on the casual observer. He made a sketch of the great comet of 1882, which was reproduced in the *Monthly Notices* (vol. xliii., page 288); and a "rough drawing of *Copernicus*," made with the Matthew Equatorial in 1876, forms the frontispiece to vol. i. of the *Observatory*. H. H. T.

Robert Crowe was born at Middleton, in the Yorkshire Wolds, on the 19th of December 1820. He obtained the degree of Master of Arts at Trinity College, Dublin, and shortly afterwards took Holy Orders. For 47 years, from 1851 to 1898, he was Vicar of Woodhouse, near Huddersfield. He made his own telescopes and was a regular observer of the planets. He became a Fellow of the Society in 1869.

He married a daughter of the Rev. C. Drawbridge, a former vicar of Honley, near Huddersfield. They had no children. He died at Woodhouse Vicarage on the 9th of November 1901.

Alfred William Drayson was born at Waltham Abbey, Essex, in 1827. He received his education at the Royal Military Academy, Woolwich, and obtained his first commission in 1846. He served in the Kaffir war in 1847, and against the insurgent Boers in 1848. In both campaigns his knowledge of the Kaffir and Zulu languages were of great service. He was appointed instructor in surveying and field works at the Royal Military Academy, Woolwich, and shortly afterwards professor of surveying and practical astronomy. During this period he was instructor to the Duke of Connaught. On returning to military duty he was appointed to command the Royal Artillery at Portsmouth. In 1876 he proceeded to India in command of his brigade, and did valuable work in the rearmament of various forts in Bengal. Upon returning to England he was promoted to the rank of General. He retired from the army in 1883, and lived at Southsea till his death on the 27th of September 1901.

General Drayson wrote a number of stories, beginning in 1858 with *Sporting Scenes among the Caffres*, and following with *Among the Zulus*, *The Gentleman Cadet*, and many others. He published books on billiards and whist, on both of which games he was an authority.

As a military writer mention may be made of his work on military surveying, which had several editions and was used as a text-book.

In his astronomical writings General Drayson went somewhat astray. In one of these he attributed what were really errors of observation to a gradual increase of the Earth's diameter; and in another he substituted a geometrical movement of the pole (which more or less accounted for the phenomena of recent years, but which was entirely empirical) for the orthodox precession,

nutation, and change in inclination of ecliptic to equator, which have a dynamical basis.

General Drayson was of a kindly disposition and made many friends. He passed a long life in great activity and rendered valuable services to his country.

He was elected a Fellow of the Society on the 10th of January 1868.

John Penn Hartree was born at Lewisham on the 14th of November 1844, and died at his residence at Cambridge on the 3rd of May 1901. He entered at Trinity College, Cambridge, in 1863, and obtained a first class in the Natural Science Tripos in 1865. After taking the degrees of M.A. and M.B. he practised for some years as a doctor, but retired from practice in 1875. His practical interest in astronomy began in 1876 and continued till 1896; he possessed a 6-inch Cooke equatorial, a small transit by Troughton and Simms, and an astronomical clock. He was elected a Fellow of the Society in 1879, but never communicated any papers. He married in April 1868 Janet, eldest daughter of Samuel Smiles, LL.D.; his wife died in 1899. They leave two sons, a daughter having died in childhood.

Lord Inverclyde, better known perhaps as Sir John Burns, was born in Glasgow in 1829. He was the eldest son of Sir George Burns, Bart., of Wemyss Bay, and Jane, daughter of James Cleland, LL.D., of Glasgow. He was educated at Glasgow University, and immediately after leaving college was associated with his father in the business of the Cunard Steamship Company.

On the retirement of the original partners he became head of the company, and its present great position has been attained through his foresight and enterprise. In addition to the great development of the Cunard Line he greatly improved the mail service between Scotland and Ireland by his fine fleet of Royal steamers which ply between those countries.

Lord Inverclyde rendered great service to the country by drawing the attention of the Government to the methods by which merchant ships could be adapted for war purposes, and by the leading part he took in connection with the defences of the Clyde when the Government took up the question of coast defence.

He took deep interest in religious and philanthropic work in Glasgow, and was President of the Clyde Industrial training-ship *Empress*, and of the Glasgow Foundry Boys' Religious Society. He died at Castle Wemyss on the 12th of February 1901. He was elected a Fellow of the Society on the 13th of November 1874.

William Lethbridge was born on the 20th of February 1825 at Tavistock. He was a schoolfellow of the Right Hon.

W. H. Smith at Tavistock Grammar School. He went to St. John's College, Cambridge, and was 9th Wrangler in 1850. He was for some time a master at Rossall and St. Paul's Schools. In 1861 he was called to the Bar and joined the firm of W. H. Smith & Son as managing partner. In 1885 he retired from active business and went to reside in his native county of Devonshire. He took an active part in the business of the county and was High Sheriff for 1893–4. For some years he was in failing health and died on 31st of March 1901.

He was elected a Fellow of the Society on the 9th of February 1855, but has not communicated any papers to the Society.

Charles Meldrum was born in 1821 at Kirkmichael, in Banffshire. He was educated at Marischal College and University, Aberdeen, and was Lord Rector's Prizeman in 1844. He entered the Bombay Education Department in 1846, and two years later was appointed Professor of Mathematics at the Royal College of Mauritius. In 1851 he founded the Meteorological Society in that Colony, and was for many years its Secretary. In 1862 he was appointed Government Observer. The principal work done at the Observatory, which was situated at Port Louis, consisted in the examination and tabulation of ships' logs. As it was surrounded by hills the locality was unsuitable for a meteorological station, and in 1863, owing to Dr. Meldrum's efforts, in which he received strong support from Sir E. Sabine, the old observatory was sold preparatory to building a new one at Pamplemousses. The foundation-stone of the new observatory, the Royal Alfred Observatory, was laid in 1870 by H.R.H. the Duke of Edinburgh. It cannot be said that the new site was very happily chosen, as the ground is marshy and fever-stricken. The Royal Alfred Observatory was provided with meteorological and magnetic instruments, a 6-inch Cooke equatorial, a 3-inch transit, and a 4-inch photoheliograph. From 1880 to 1885 sun-pictures were taken regularly on a scale of 4 inches, and from 1885 to the present time on the enlarged scale of 8 inches to the Sun's diameter.

Dr. Meldrum was more interested in meteorology than astronomy, and his principal work was in connection with the law of storms in the Indian Ocean. He discovered that the diurnal barometric variation was very regular, and that a slight deviation indicated strong disturbance at a more or less great distance. His knowledge of the prevailing winds, &c., enabled him to advise vessels proceeding from Mauritius where cyclones would be met.

The British Association Reports for 1874 and 1876 contain papers in which he tabulated the number of cyclones in the years 1856 to 1875, their duration, the distances they travelled, and the areas over which the wind blew with the force of a strong gale. He compared these with Wolf's relative sun-spot numbers, and

concluded that cyclones were fewest and least severe at a Sun-spot minimum and the converse at a maximum. He also tabulated the rainfall in different years at a large number of stations distributed over the Earth, and concluded that the total amount of rain which fell on the Earth was above the average at times of sun-spot maxima and below at minima. Neither of these conclusions has as yet been sufficiently confirmed to be beyond doubt.

Dr. Meldrum was elected a Fellow of the Society on the 11th of March 1870. He communicated to the Society in 1873 a paper on "Star Showers seen at Mauritius."

The degree of LL.D. was conferred on him by the University of Aberdeen in 1876, and in the same year he became a Fellow of the Royal Society. He was made C.M.G. in 1886, and served as a member of the Council of Government of Mauritius from 1886 to 1896. After his retirement in 1896 he lived in Edinburgh, where he died on the 28th of August 1901.

Sir Cuthbert Peek, the only child of Sir William Henry Peek, the first Baronet, was born on the 30th of January 1855, and succeeded to the baronetcy on the death of his father in 1898. He was educated at Eton and Pembroke College, Cambridge. After leaving Cambridge he went through a course of instruction in astronomy and surveying, and put his knowledge into practice in two journeys across the unfrequented parts of Iceland, taking regular observations of the latitude, longitude, and dip of the needle. On his return to England he established a small observatory with a 3-inch equatorial in his father's grounds. In 1882 he accompanied the British expedition to Australia to observe the transit of *Venus*, the party consisting of Captain Morris, R.E. (in charge of the expedition), Lieut. Darwin, R.E., and an assistant. Mr. Peek took with him a 6·4-inch equatorial and a portable observing hut. The expedition arrived at Brisbane on the 27th of October, and a few days later left for Jimbour, a well-chosen station, with an uninterrupted view of the horizon in all directions. The six weeks preceding the transit of *Venus* were occupied with observations of double stars, nebulæ, and clusters, and especially of the nebula surrounding η *Argus*, on which Mr. Peek published an interesting memoir after his return to England in August 1883. On the 7th of December, the morning of the transit of *Venus*, the sky was completely overcast, although there had been only two cloudy nights in the previous six weeks. In 1884 Mr. Peek built the Rousdon Observatory and furnished it with a 6·4-inch Merz refractor equatorially mounted, a small transit instrument, and a sidereal clock. From this date he carried on a continuous series of observations of variable stars of long period, and reports of his observations will be found each year since 1887 in the February number of the *Monthly Notices*. When Mr. Peek's observations began the difficulties of

observing long-period variables were considerable, as the observers had to determine the magnitudes of the comparison stars. These difficulties were removed in 1890 by the publication of charts and catalogues of comparison stars for variables by the Harvard College Observatory. Observations made before the 31st of December 1890 were corrected to the Harvard data, and since then the Harvard photometric magnitudes of the comparison stars have been used. Argelander's method of observing was adopted, and each observation of a variable was made by comparison with five stars of known magnitude in the same field. To the end of 1900 6,809 observations had been made and 267 maxima and 227 minima had been determined. Papers showing the light changes of ten variables have been published, and the whole of the observations made at the Rousdon Observatory, which are of great value, will appear in a volume of the *Memoirs* of the Society. Meteorological observations were also carried on, and weekly and monthly weather reports were issued from the Rousdon Observatory.

Sir Cuthbert Peek was elected a Fellow of the Society on the 11th of January 1884.

In 1884 he married the Hon. Augusta Louisa Broderick, eldest daughter of Viscount Middleton, and he leaves two sons and four daughters. He died on the 8th of July 1901.

Basil Woodd Smith was born in London on the 9th of March 1831. He was intended by his father for the Stock Exchange, but finding the work entirely uncongenial he soon abandoned it. Placed in circumstances which permitted him to give his time and counsel where they were needed, he was able to assist a number of good causes. He lived at Hampstead, and was chairman of the bench of magistrates. He assisted the local philanthropic institutions, and was for many years chairman of the Orphan Working Schools. He was a man of strong religious views, and was largely occupied in the work of the Bible Society, attending the committee meetings with great regularity for a long period. He also took great interest in Palestine exploration, and generally in all questions of Biblical archæology.

Although a good classical scholar, his interests were scientific rather than literary. He was for many years on the board of managers of the Royal Institution, and attended the lectures with great regularity. He frequently observed with a telescope he had erected on the roof of his house, and was always ready to show it to visitors and answer the questions they put to him. He was elected a Fellow of the Society on the 10th May 1861, and till recently was a regular attendant at the meetings.

Mr. Woodd Smith was twice married, and leaves eight children.

Henry Augustus Rowland, the son of the Rev. H. A. Rowland, D.D., was born at Honesdale, Pennsylvania, on the

27th of November 1848. He studied engineering at the Rensselaer Polytechnic Institute at Troy, and received the degree of Civil Engineer (C.E.) in 1870. For a short time he was a railway engineer. In 1871–2 he was science teacher at Wooster College, and from 1872–5 was assistant professor at Troy. On the 3rd of April 1876 he was appointed Professor of Physics and Director of the Physical Laboratory of the Johns Hopkins University of Baltimore, and for twenty-five years added lustre to his university by his own brilliant researches and by the band of workers he stimulated to devote themselves to the progress of physical science.

Professor Rowland's first important paper was on magnetic permeability. This work he sent to Clerk Maxwell in 1873, who replied that he was sorry he could not communicate it to the Royal Society, as that Society was not in session, but that he had sent it to the *Philosophical Magazine*, and would himself, as Rowland was so far away, correct the proofs. Before taking up his professorial work he studied a little time in Berlin, and in 1876 made the important discovery that a moving charge of static electricity, like a current, sets up a magnetic field. He made an excellent determination of the mechanical equivalent of heat, but with this exception his researches alternated between electric and magnetic subjects and those spectroscopic researches for which astronomy is so greatly indebted to him.

Professor Rowland's spectroscopic work began in 1882, in which year he published a "Preliminary Notice of Results accomplished in the Manufacture and the Theory of Concave Gratings for Optical Purposes." It is well known how imperfect were the tables of wave lengths before Professor Rowland's time, and how his researches required him first to perfect the concave grating, and how this forced him to make his perfect screw and unrivalled dividing engine. His process of making screws is described in an article by him in the *Encyclopædia Britannica*, and an account of the ruling of concave gratings is given in *Phil. Mag.* for 1882.

After ten years' work with many gratings of 6 inches diameter and 21½ feet radius, in the course of which thousands of solar and metallic lines were measured by himself and his assistant, Mr. Jewell, Professor Rowland published in 1893 a table of standard wave lengths extending from λ 2000 to λ 7700, and containing about 1,000 lines. The publication of Rowland's "Preliminary Table of Solar Wave Lengths" was begun in January 1895 in the *Astrophysical Journal* and finished in 1897. It extends from λ 2975 to 7330, and contains about 20,000 lines, and is by far the fullest catalogue of the solar spectrum yet attempted. The strong lines are nearly all referred to the element producing them, and in connection with this work Professor Rowland had obtained photographs of the spectra of all the known elements except gallium, and at intervals the results derived from the measures of these spectra

by him and his pupils appeared in the *Astrophysical Journal* as "Tables of the Arc Spectra of the Elements."

Professor Rowland's personal character is well described in the following extract from an eloquent address by Dr. Gilman, the President of the Johns Hopkins University: "Above his keen perceptions, his logic, his adaptation of means to ends, and his marvellous concentration I must place his love of truth. He was true in all his investigations, careful to eliminate errors, to avoid misconceptions, to shrink from hasty conclusions and inferences, to be critical of other investigations, to be accurate, exact, conscientious, to spare no pains, to shrink from no efforts, to conceal no difficulties, in order that the absolute facts might be established, as far as this can be done, by limited humanity. To him science was another word for truth—not all the truth, but that amount of truth which the limited powers of man have discovered. He was a follower of Isaac Newton, picking up from the seashore a few pebbles and discerning their lessons."

Professor Rowland was a member of many learned societies in Europe and America. He was elected an Associate of the Royal Astronomical Society on the 9th of December 1898. He died at his home in Baltimore on the 16th of April 1901. His body was cremated and the ashes buried beneath his famous ruling engine.

Truman Henry Safford was born on the 6th of January 1836, at Royalton, Vermont. In extreme youth he possessed extraordinary powers of arithmetical calculation, of which an account is given in *Chambers's Edinburgh Journal* for October 1847. These powers were not in his case intuitive, but were improved by study and practice, and at a very early age he obtained a knowledge of algebra and geometry. His father wisely decided to give him a good education, and at the age of ten he was placed under the charge of Professor Everett and Professor Peirce at Harvard College. In 1854 he graduated at Harvard, and immediately obtained employment at the Observatory. He remained at Harvard College Observatory for twelve years, and during this time published a number of Elements and Ephemerides of Comets and Minor Planets in the *Astronomical Journal*, and contributed several papers to the *Monthly Notices*. The most interesting of the latter is a determination of the orbital motion of *Sirius* from the observations of declination. In 1860 he prepared a Catalogue of the Declination of 532 Stars culminating near the Zenith of the Harvard College Observatory, for use in the survey of the Great Lakes in the determination of latitude by Talcott's method. In 1865, after the death of Professor Bond, Professor Safford was for a short time in charge of the Observatory. During this time he brought out vol. iv. of the Annals, consisting of a Catalogue of Standard Right Ascensions of Clock Stars and Close Polars. He also edited

vol. v., "Observations upon the Great Nebula of *Orion*," which was left unfinished by Professor Bond.

In 1866 Professor Safford was appointed first Director of the Dearborn Observatory at Chicago, and devoted himself to observations of nebulæ with the 18-inch equatorial. In consequence of the great fire of 1871, the Observatory, which was supported by private munificence, could no longer be maintained, and Professor Safford from 1871–1876 was obliged to leave astronomy for geodetic work for the United States Government. In the latter year he was appointed Professor of Astronomy at Williams College, Williamstown, Massachusetts, a post which he continued to hold till his death on the 13th of June 1901. Although his professorial duties left him but little time for research, his interest in the progress of astronomy was maintained, especially in the improvement in the accuracy of right ascensions and declinations of stars both by further observation and also by discussion of existing star catalogues. He chose as his particular field the region near the North Pole, and brought out a catalogue of the right ascensions of 133 stars within 10° of the Pole, and contributed to the *Monthly Notices* several papers on the comparisons of various catalogues in this part of the sky.

Professor Safford was a devoted and painstaking astronomer, and in the course of the nearly fifty years of his astronomical career he accomplished a considerable amount of useful work. He was elected an Associate of the Society in 1866.

Christian Wilhelm Schur was born at Altona on the 15th of April 1846. He was a relative of Dr. Petersen, the Director of the Altona Observatory, from whom he derived an early inclination to astronomy. In 1863 he went to the University of Kiel and proceeded to Göttingen in 1866, where he obtained his doctor's degree for a thesis on the orbit of 70 *Ophiuchi*. From Göttingen Dr. Schur went to Berlin and assisted Dr. Auwers in the re-reduction of Bradley's Observations, and afterwards worked for some time at the Observatory with Dr. Foerster. He was next appointed an assistant at the Geodetic Institute, where he remained till 1873, when he received an invitation from Dr. Winnecke to the Observatory at Strassburg, which had been recently rebuilt. He continued as an observer at Strassburg for ten years, except that in 1874 he went to the Auckland Islands with Drs. Seeliger and Wolfram to make heliometric observations of the transit of *Venus*. While at Strassburg he made heliometric observations of *Jupiter's* satellites, and made a large number of observations of variable stars. He succeeded Winnecke as Director of the new observatory, and spent some years in getting it into order. In 1886 he became Director of the Göttingen Observatory. Here his first task was the publication of Klinkerfues' Zone Observations. When this was finished he was able to devote himself to observations with the Repsold 6-inch heliometer. He

investigated the errors of the instrument with the utmost care and executed three very laborious triangulations—*Praesepe*, *h Persei*, and χ *Persei*—work which was planned and begun, if not finished, before the advantages of photography for this class of observations was generally appreciated.

In co-operation with Dr. Gill he made extensive triangulations of the comparison stars of *Victoria*, *Iris*, and *Sappho*, and many observations of these planets at their oppositions in 1889 for the determination of the solar parallax. Under Professor Schur's direction a re-reduction of Olbers' Comet Observations was made by Dr. Stichtenoth was made in 1898, and appears as a supplement to Schilling's *Life of Olbers*.

Professor Schur died on the 1st of July 1901, at the age of fifty-five, after a long and severe illness. His whole life was spent with unremitting industry in the service of astronomy. He was elected an Associate on the 9th of December 1898.

Proceedings of Observatories.

The following reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.

Transit Circle.—During the year 1901, 11,416 observations of transits and 10,048 of zenith distances have been obtained. The total number of stars observed is about 5,000, of which 1,400 are within 10° of the pole. Half the ten years allotted to the observations for the new Star Catalogue, which will contain about 11,500 stars, are now elapsed, and it is satisfactory to be able to report that rather more than half of the work has been done, about 26,000 observations of the 10,000 zone stars having been obtained. The Sun has been observed 190 times with the transit-circle, its horizontal diameter 160 times, and its vertical diameter 180 times. The Moon has been observed 122 times in R.A. and N.P.D.: the mean error in R.A. of Hansen's Lunar Tables with Newcomb's corrections is $-0^s\cdot141$. The errors since 1883, when Newcomb's corrections were introduced into the *Nautical Almanac*, are as follows:—1883–1893, $+0^s\cdot043$; 1894–1896, $-0^s\cdot057$; 1897–1901, $-0^s\cdot137$.

The R − D discordance shows an increase on values found in 1899 and 1900, the correction to the D observation being—

$+0''\cdot08 + 0''\cdot22$ sin Z.D. in 1899,
$+0''\cdot09 + 0''\cdot32$ sin Z.D. in 1900,
$+0''\cdot06 + 0''\cdot44$ sin Z.D. in 1901.

Good progress has been made in the re-reduction of Groombridge's observations. The years 1806–1810 are completed, and 1811 is in hand. It is hoped that the re-determination of the mean R.A. and N.P.D. for the remaining years will be finished by the end of this year. Most of the stars in Groombridge's Catalogue which are found in Newcomb's Fundamental Catalogue were observed in the period 1806-1810 by Groombridge, and these stars have been used to determine indirectly the division errors, the accordance of the results from stars north of the

zenith with those south of the zenith in the reversed position of the instrument furnishing a satisfactory check on the values. The re-reduced places from Groombridge's observations of the stars in the *Berliner Jahrbuch* which were observed in the years 1806 to 1810 have been sent to Dr. Auwers at his request for use in the preparation of his Fundamental Catalogue.

The Altazimuth.—As much inconvenience has been occasioned through the breaking of the spider lines, which have an unnecessarily long span, the micrometer slides have been altered so as to reduce the span from 1·5 inch to 0·8 inch in R.A. and 0·6 inch in N.P.D. The instrument was out of use from Sept. 6 to Oct. 21, while this alteration was being made. In the meridian the altazimuth has been used as a reversible transit circle in all four positions. During the year 2,271 meridian observations of the Sun, Moon, planets, and stars in R.A., and 2,121 in N.P.D. have been made. The nadir has been observed 593 times, 124 reflexion and direct observations of stars have been made, and 10 determinations of flexure have been obtained. The Moon has been observed 26 times on the meridian. Out of the meridian 107 azimuths and zenith distances of stars and 12 of the Moon have been obtained. New determinations for division error of the circles have been made for every 15° by the one-circle, and for every 5° and 1° by the two-circle method, and the previous determinations have been collected and combined with these, and definitive corrections for division error adopted for reduction of the circle observations. The observation of *Eros* comparison stars has been continued, and at present, out of the 319 stars in M. Loewy's first list, 144 have been observed three times, 52 twice, and 70 once; while of the 352 stars in the second list, 86 have been observed three times, 49 twice, and 61 once. Observations of reference stars for Dr. Gill in connection with heliometer observations of the major planets have also been continued. The printing of the observations for 1899 and 1900 has been begun. These observations will be published in the Greenwich volume for 1900.

Suitable computing forms for the reduction of the extra meridian observations have been arranged and some subsidiary tables formed to facilitate the reductions.

Equatorials.—Occultations of 16 stars by the Moon have been observed by one or more observers during the year. These observations are printed in *Monthly Notices*, vol. lxii. 4.

28-inch Refractor.—Measures of distance and position-angle of 406 double stars have been made during the year, each star being observed on the average on $2\frac{1}{2}$ nights. Of the 406 stars—

120 were under $0''\cdot5$ apart,

104 were between $0''\cdot5$ and $1''\cdot0$,

97 were between $1''\cdot0$ and $2''\cdot0$.

The remaining 85 are generally third companions of close pairs or difficult on account of the difference of magnitude.

All close and rapid binaries are kept under constant observation as well as all the difficult stars observable in this latitude, for which a large telescope is required. The following list gives some of the stars measured during the year :—

Star.	Mags.	Dist.	Star.	Mags.	Dist.
		"			"
β 1266	7·2 , 7·5	0·1	42 Comæ	5·5 , 5·9	0·3
β 524	6·0 , 7·0	0·2	γ^2 Androm.	5·0 , 6·2	0·3
β 525	7·0 , 7·0	0·2	Σ 234	7·0 , 7·4	0·3
Σ 2367	7·0 , 7·5	0·2	OΣ 225	5·2 , 11·2	0·8
ε Hydræ A.B.	3·5 , 6·0	0·2	Aldebaran	1 , 14	31·4
ζ Bootis	3·5 , 3·9	0·2	β 733	6·0 , 11·0	0·7

In addition good series of observations have been obtained of—

Star.	Mags.	Dist.	Star.	Mags.	Dist.
		"			"
κ Pegasi	3·9 , 5·0	0·1	ζ Herculis	3·0 , 6·5	0·9
β 883	7·0 , 7·0	0·1	70 Ophiuchi	4·1 , 6 1	1·5
δ Equulei	4·5 , 5·0	0·1			

The observations of *Capella* as a double star have been continued at every favourable opportunity during the year, and a certain number of measures have been secured, but the weather generally has not been sufficiently favourable for observations of this and other very difficult objects, especially in the latter half of the year.

Thompson Equatorial.—With the 26-inch refractor 100 photographs of *Eros* were obtained on 41 nights. A few photographs of the satellites of *Jupiter*, *Uranus*, and *Saturn* have been obtained, but the low declinations of these planets prevented any long series from being obtained. Since 1902 January 1 some good photographs of *Neptune* and its satellite have been obtained. With the 30-inch reflector 14 photographs have been taken for the nebulosity round *Nova Persei*. Photographs taken on December 4 (exp. $3^h\ 45^m$) and on December 9 (exp. $4^h\ 34^m$) show a trace of the nebula. It is shown more clearly on photographs taken December 10 (exp. 6^h), December 16 (exp. $4^h\ 48^m$), and December 18 (exp. $5^h\ 30^m$). These photographs are not entirely satisfactory, as the images have become displaced during the long exposure. The spectroscope was in use from March (when the mirror of the reflector was resilvered) to November, and 76 photographs of spectra of the brighter stars have been obtained. Some of these have been measured and are quite satisfactory, but in others displacements have been found in the

comparison spectra taken at the beginning and end of the exposure in different positions of the instrument. With a view to remedying this, the collimators and camera have been more firmly clamped and all parts examined to guard against possibility of shift. The spectroscopic observations were temporarily discontinued at the end of November, the reflector being in use for photographing the nebulosity round the *Nova*.

Astrographic Equatorial.—566 plates have been taken during the year on 139 nights. Of these, 56 have been rejected—viz. 12 because the exposure was interrupted by cloud or the plate did not come up to the standard in showing faint stars, 15 on account of fault of guiding or setting, 18 owing to photographic, and 11 for miscellaneous defects. Of the 510 successful plates, 128 were of *Eros*; 153 of *Nova Persei* and field, and 100 of the *Nova* and neighbouring stars of approximately the same magnitude; 87 for the chart, 36 for the catalogue and 6 for adjustment of the equatorial. The number of successful fields taken during the year is 82 for the chart and 34 for the catalogue. These photographs have been taken to replace some of the poorer photographs already taken. Successful photographs of more than 1,100 fields out of the 1,149 required are on the shelves. During the year 1901 positives on glass of 144 chart plates were made, which brings the total number to 1,254, of which 150 are duplicates.

During the year 1901, 112 plates were measured, both in direct and reversed positions of the plate, by two measurers, who measured the 6^m and 3^m images respectively. The measurement is now completed for the Greenwich zones from Dec. $+64°$ to Dec. $+76°$, and to Dec. $+77°$, as far as 20^h, making a total of 800 plates out of 1,149, or 1,545 square degrees out of 2,088.

The measures of 210 plates have been printed during the year. All the measures between Dec. $+64°$ and Dec. $+71°$ are now in type, corresponding to 478 plates covering 964 square degrees. The number of stars measured in this area is 68,922, or rather more than 71 per square degree.

The number of stars shown with 40^m exposure has been counted on 162 chart plates during the year. The counting up to the present time has been completed for the area from Dec. $+65°$ to Dec. $+69°$, and to Dec. $+70°$ as far as 6^h, or for about 320 plates, covering 600 square degrees.

The following table, in continuation of one given last year, gives the number of stars in Zones 67°, 68°, and 69° from 0^h to 6^h, obtained with exposures of 40^m, 6^m and 3^m, and 20^s, compared with the numbers given in the B.D., and the number given in that work down to $9^m{\cdot}0$. The first line for each zone gives the total number of stars shown, and the second line the number of stars shown twice—*i.e.* on each of the overlapping series of plates. The totals refer to all the plates counted up to the present time, Zones 65° to 69°.

Zone.	No. of Sq. Degrees.	Number in B.D. $9^{m}\cdot0$ and brighter.	Number in B.D. Total number.	Number shown on Photographs. Exposure 20^{s}.	Exposure 3^{m} and 6^{m}.	Exposure 40^{m}.
67°	138	624	1,577	1,849	9,587	44,489
				1,201	7,236	39,188
68°	132	529	1,470	2,103	9,939	45,553
				1,277	8,006	40,947
69°	32	148	364	650	2,763	15,272
($0^{h}\cdot0^{m}-6^{h}\cdot0^{m}$)				346	2,250	13,133
Totals 65°–69°	595	2,695	7,160	9,233 5,591	41,033 31,814	197,727 171,300
Number per Square Degree		4·5	12·0	15·5 9·4	69·0 53·5	332·3 287·9

The ratios of these numbers to the number of stars given in the B.D., *i.e.* to column 4 of the above table, are—

Zone.	$9^{m}\cdot0$ and brighter.	Total No. in B.D.	Exp. 20^{s}.	Exp. 3^{m} and 6^{m}.	Exp. 40^{m}.
67°	·396	1	1·171	6·08	28·2
			0·762	4·59	24 8
68°	·360	1	1·431	6·76	31·0
			0·869	5·45	27·9
69°	·407	1	1·786	7·59	42·0
($0^{h}-6^{h}$)			0·951	6·18	36·1
Means	0·376	1	1·290	5·73	27·6
65°–69°			0·781	4·44	23·9

Photoheliograph.—Photographs of the Sun have been obtained on 163 days; those on 43 days were taken with the Thompson photoheliograph of 9 inches aperture, and those on the remaining 120 days—viz. between February 15 and September 19, whilst the Thompson instrument was dismounted for use in the eclipse expedition of 1901 May 18—with the Dallmeyer photoheliograph of 4 inches aperture. Of the photographs taken, 339 have been selected for preservation, including 15 with a double image of the Sun, taken to determine the position of the wires with reference to the parallel of declination. Photographs have also been received from India up to 1901 December 4, and from Mauritius up to 1901 September 11, the year ending on the former date being represented on 359 days out of the 365 by a photograph from one or other of the three observatories. The measures and reductions for 1900 have been completed and the results wholly passed for press. The Greenwich photographs for 1901 have also been completely measured. The measures and reductions for the photographs from India are complete up to 1901 October 12, and for those from Mauritius as far as received. There can be little doubt that the minimum of the Sun-spot cycle has occurred

during the past year, the solar activity, as shown in the numbers and areas of Sun-spots, having been remarkably small. The mean daily spotted area of the Sun, expressed as usual in millionths of the visible hemisphere, had fallen from 1464 for 1893, the year of maximum, to 111 in 1899 and 75 in 1900, and a preliminary estimate for 1901 places the figure for that year as under 30. This is much below the figure for 1889, the year of minimum in the preceding cycle, which was 78, and is practically the same as that in the year of minimum in the cycle before, 1878, when the area was 24.

M. Loewy came to Greenwich in June and discussed with the Astronomer Royal the details for the redetermination of the Paris-Greenwich longitude referred to in the last Report. It was arranged that the operations should be carried out in the spring and autumn of 1902. The four observers (two French and two English) will use transit instruments of identical form, the four which were used by the British observers in the Transit of *Venus* expedition of 1874. Two of these, D and E, were sent to Paris in October, and M. Loewy reports that he finds them satisfactory. Trial observations with B and C are being made at Greenwich.

Mr. Dyson and Mr. Maunder went out on the part of the Royal Observatory to Sumatra and Mauritius to observe the eclipse of the Sun on 1901 May 18, and secured a valuable series of photographs. Preliminary accounts of their observations were read at joint meetings of the Royal and Royal Astronomical Societies on October 31, and are printed in the *Proceedings of the Royal Society*, vol. lxix., and also as an appendix to vol. lxii. of the *Monthly Notices.*

The printing of the volume of *Greenwich Observations for* 1899 is completed, and a specimen copy has been received. The volume for 1900 is printed as far as the end of the Annual Star Catalogue. The heliographic results are also printed. It is hoped that a first volume of astrographic measures, embracing the zones from declination 64° to declination 72° (about one-half of the part undertaken), may be published by the end of 1902.

The re-arrangement of the library and preparation of card catalogues has been continued, and is within a short distance of completion.

Royal Observatory, Cape of Good Hope.

The 24-inch object-glass of the McClean telescope, which had been sent to Sir Howard Grubb for correction in 1899 October 31 was received in 1901 February 16. After exhaustive tests it was found to be somewhat improved as to chromatic correction, and the images towards the edges of the photographic field free from coma; but the minimum focus remains still on the less refrangible side of Hγ, and not on the more refrangible side as was desired. The object-glass has been accepted.

This completion of Mr. McClean's munificent gift was marked by the uncovering of the Inscription Stone by His Excellency the Governor (the Hon. Sir Walter Hely-Hutchinson) on September 19.* The stone bears the inscription :—

1897. THE VICTORIA TELESCOPE.

THE GIFT OF FRANK MCCLEAN,

OF RUSTHALL, KENT.

DAVID GILL, H.M. ASTRONOMER.

(This stone was cut during Mr. McClean's visit to the Cape in 1896, when there was every expectation that the instrument would be completed in the year of Queen Victoria's Jubilee.)

His Excellency stated that it had been the desire of H.R.H. the Duke of Cornwall and York to perform that ceremony on the occasion of his recent visit, but owing to the great number of public engagements which had been pressed upon His Royal Highness it had fallen to his (the Governor's) part to do so.

The iron bed-plate of the new transit-circle reached the Observatory in March, the piers and remainder of the instrument, except the collimators, in April.

No difficulty was experienced in erection and adjustment, but a great deal of time was given to experimental work in connection with insulating the piers from heat and in improving the methods for illuminating the microscopes, &c.

The instrument is uncovered, for observing, by rolling back the two halves of the steel Observatory. An admirably working plan has been carried out for opening and closing the Observatory by an electro-motor, instead of the hand motion originally supplied ; the latter involved more labour than it was desirable to impose on an observer about to undertake delicate observations.

The most serious difficulty connected with the erection of the transit circle was found in the geological conditions of the site. H.M. Astronomer was desirous that, besides the ordinary collimators, there should be meridian marks in the foci of lenses of about 300 feet focus, both to north and south of the instrument. To insure the necessary stability it seemed requisite that the lenses and marks should rest on foundations built upon the solid bed-rock. When excavations had been made to north and south of the instrument for foundations of the collimator piers, it was found, at the depth of 12 feet, that nothing better than weathered rock could be found—a foundation amply sufficient for any ordinary building, but useless for that of a meridian pillar.

Accordingly a rock-boring apparatus was erected successively over the four required sites, and the bores were continued at

* The writer regrets a mistake which occurs in his speech made on that occasion, viz., the statement that Huggins undertook researches on the motion of stars in the line of sight at Clerk Maxwell's suggestion. It is now clear that that work had been begun without any previous consultation with Clerk Maxwell.

each site until the cores brought up by the diamond drill showed that the unweathered rock of the Malmesbury beds, free from crack or fissure of any kind, had been reached. The corresponding depths were :—

South meridian mark, 24½ feet ; south collimator pier, 30½ feet.
North meridian mark, 16½ feet ; north collimator pier, 34 feet.

As piers of such height could not be relied upon for permanency, H.M. Astronomer devised a plan by which the optical centres of the two long focus lenses and the centres of the two meridian marks could be rapidly and accurately adjusted, at any moment, vertically over the corresponding optical centres of lenses attached to the bed-rock below. Thus all azimuths could be referred to bearings defined by points attached to the solid rock.

The Admiralty having sanctioned the necessary cost, the work of sinking the shafts has been begun. Having regard to the depth below the surface of the ground and the age, thickness, extent, and uniformity of the quartzose Malmesbury beds, the proposed system of meridian marks will probably prove to be the most stable of any yet erected. When the work has been completed and the results tested an account of the method will be communicated to the Society.

The errors of fifteen out of the sixteen microscopes belonging to the instrument have been thoroughly investigated and the corresponding corrections computed.

Some experiments still in progress with regard to illumination of the circle of microscopes have to be completed before investigation of the division errors is undertaken.

The sinking of the water-tight shafts for giving access to the underground meridian marks and the erection of the collimators, long focus lenses, and overground marks will occupy at least six months, during which time it will probably be possible to complete the investigation of the errors of division of the circle and the pivot errors.

The annual results of meridian observations, made under the direction of Mr. Stone, 1878–79, have been printed, thus completing the issue of results of all the work done under his direction.

The printed copies of annual results, 1896 and 1897, were by inadvertence sent to the Cape, whence their distribution by post would have been unduly costly. In obedience to Admiralty orders they were returned to Greenwich for distribution in the regular way.

The annual results, 1898 and 1899, completing the meridian observations of the astrographic catalogue-plate standard stars for the zones $-40°$ to $-52°$, have also been printed. This volume was also by inadvertence sent to the Cape, and has since been returned to Greenwich for distribution along with the companion volume 1896–7.

The catalogue of 8560 stars for 1900, derived from the above-mentioned observations, is now complete in MS., except the derivation of the proper motions. The preparation of the catalogue has involved applications of corrections in R.A. depending on magnitude to the separate observations of each observer, and the formation and application of systematic corrections to each zone, both in R.A. and declination, in the manner described in the introduction to the annual volumes in question. These corrections have produced a very marked improvement in the agreement of the separate results.

The Cape Catalogue for 1900, as thus formed, has been compared with Gould's Zones, the Cordoba General Catalogue, the Cape Catalogues for 1840, '50, '60, '65, '80, '85, '90, the Melbourne Catalogues for 1870 and '80, and is in course of comparison with Downing's new edition of Taylor's Madras Catalogue. The whole catalogue, with the resulting proper motions, will probably be ready for press before the end of the current year. The observations of clock, azimuth, and miscellaneous stars observed 1896–99 have been reduced to 1900 and will form a small supplementary catalogue.

The day numbers for 1903 (corresponding to Finlay's star-correction tables) were distributed along with last year's report; those for 1904 are in the hands of the printer.

The occultations observed between 1881–1895, both inclusive, have been reduced and compared with Hansen's tables. The MS. is in the hands of the printer and will form Part 3 of Vol. II. of the *Annals of the Cape Observatory*.

The general work of the transit circle has been confined to observations of stars of the new working list (see Report, February 1900). The observations made with the transit circle have been :—

Number of transits ...	... ...	6872
Determinations of Z.D.	... ...	6248
,,	collimation	92
,,	level	320
,,	azimuth	356
,,	run	307
,,	nadir	306
,,	flexure	19

The reductions of the meridian observations to apparent place are complete in R.A. to November 30 and in N.P.D. to November 21. The corrections to mean place are complete for 1900 and for about one-third of 1901.

Reductions to mean place have also been computed for the Dublin meridian observations of zodiacal stars.

Observations of 97 separate phenomena of occultations of stars by the Moon were obtained as follows :—

	D.B.	R.B.	D.D.	R.D.	Total.
Phenomena predicted by N.A. Office	2	1	19	13	35
Other occultations	—	—	60	2	62
					97

Of these occultations 13 stars were observed by 2 observers.

" " 3 " " " 4 "

Encke's Comet was looked for on three nights but not seen. The observations of Giacobini's Comet, secured in 1900 December, were published in the *Ast. Nach.* 3741.

Some photographs and rough "circle places" of the Great Comet of 1901 are published in the *Monthly Notices*, lxi. p. 508.

Additional observations on one night with the 18-inch, and on twenty-nine nights with the 7-inch equatorial are published (*Ast. Nach.* 3733).

The weather during 1901 has been exceptionally unfavourable. During the month of January the rainfall amounted to 5 inches, whilst the average rainfall for the same month is 0·75 inch; the greatest rainfall ever previously recorded is 2·5 inches. The general character of the definition throughout the year was much worse than usual.

With the 18-inch visual telescope *α Centauri* has been measured as a double star on six days by Gill and twenty-seven days by Innes.

Mr. Innes has besides made 342 complete sets of measures (distance and position angle) of 224 different pairs of double stars, and has detected 36 previously unrecorded double stars during the year, viz. :—

With the 18-inch 13 pairs, of which 8 are under 1″ distance.

" 7-inch 18 pairs.

Three previously unrecorded double stars have also been detected by Mr. Pett with the transit circle, and two by Mr. Woodgate in examining the catalogue plates.

The most interesting of the new pairs are :—

	Distance.	
	″	
τ_2 *Lupi*	0·3	
h 4625, chief star	0·3	
U.A. 13½ *Horologii*	0·25	
φ Argûs	20	faint comes

Variable stars requiring observations for determination of their elements were observed by Mr. Innes throughout the year. In course of the observations several new variables have been discovered. Particulars in advance of publication have been sent to Professor Müller, at Potsdam, for incorporation in the new A.G. Catalogue of variable stars.

These investigations will form part of "A Revision of the Cape Photographic Durchmusterung" (*Cape Annals*, vol. ix.), of which the following parts are ready for press :—

1. Revision of Kapteyn's lists. (In hands of the printer.)
2. Examination of stars suspected of variability.
3. Observations of proved variables.
4. Observations of stars marked * or ? by Kapteyn in the C.P.D.
5. List of *errata* in catalogues of southern stars.
6. List of coloured stars observed in course of the revision.

To these will be added a list of stars having considerable proper motions. This list is waiting for the results of meridian observations not yet completed.

The testing of the 24-inch object-glass was begun on February 21 and continued with varying separation of the lenses until April 18, when the object-glass was accepted.

As mentioned in last year's report to the Admiralty, the somewhat yellow colour of the three prisms of the line of sight spectroscope produced an undue absorption of light in the region between H_γ and H_δ; and Mr. McClean, with his wonted generosity, provided for a new battery of four prisms of very transparent glass giving together rather less dispersion and the same deviation as the three original prisms of very heavy glass. In consequence of a cable message from the Cambridge Instrument Company to the effect that the new prisms by Hilger were ready, the spectroscope was shipped to Cambridge on April 18—a few days before the appearance of the great comet. The spectroscope has not yet been returned to the Cape.

The 10° object-glass prism still remains undelivered by Messrs. Zeiss.

The $8\frac{1}{4}°$ objective prism has been employed by Mr. Lunt in photographing faint stars having peculiar spectra, and for visual searching for star-like nebulæ.

Ninety negatives, mostly of long exposure, have been secured, and two star-like nebulæ have been found by Mr. Lunt by visual sweeping with the objective prism.

Their places are :—

	1900.		
	h m s		° ′
R.A.	10 56 28	Decl.	−64 43
	17 49 6		−21 47

Mr. Lunt has also been engaged on an elaborate investigation of the spectrum of Silicon with the new laboratory spectroscope by Hilger.

The heliometer, which has been in constant use since 1887, was dismounted in March and completely taken to pieces. Its various parts were repainted, repolished or relacquered, and some convenient changes in the way of new switches and carbon

resistances for regulation of the illumination were introduced. The work occupied three and a half months and was admirably done by Mr. Miller, the optical fitter attached to the Observatory, who had just returned from service at the front.

In consequence of these repairs the opposition of *Uranus* was lost, but the following oppositions of major planets were observed :—

	No. of Observations.
Opposition of *Mars*	48
,, *Jupiter*	22
,, *Saturn*	28

(On account of bad weather *Neptune* was not observed until early in 1902 January, but 30 observations have been secured previous to January 11.)

The triangulation of the comparison stars for *Uranus* 1897–1900 and *Saturn* 1898 has been completed by 21 observations of distance and 9 of position angle.

The triangulation of the comparison stars for *Neptune* 1897–1900 has been completed by 45 measures of distance including standards.

Forty-eight supplementary measures of distance (including standards) have been also made in connection with the triangulation of the South Polar area.

H.M. Astronomer has gratefully to acknowledge very valuable series of observations of comparison stars from the principal meridian observatories.

The Polar triangulation includes 22 stars situated within 2 degrees of the pole, and these offer 122 distances, all of which were measured from three to six times each with the heliometer. In other words, the observations afford 122 equations of condition for determination of 44 unknown coordinates. These equations have been formed and solved. The results have been forwarded to Professor Harold Jacoby as a basis for his discussion of an early Cape series of circumpolar photographs.

The details of the heliometric triangulation are in course of preparation for press.

An extension of the circumpolar triangulation has been planned extending to stars 6° from the pole, and 137 observations of distance (including standards) have been made in connection with that work.

Forty-eight heliometer observations of *α Centauri* as a double star have been made.

Mr. Bryan Cookson between June 24 and September 27 made heliometer measures on thirty-eight nights of the mutual distances and position angles of *Jupiter's* satellites on the same plan as that of Gill's observations in 1891. From 28 to 30 complete observations both in distance and position angle have been secured for each pair of satellites. A pair of standard

stars was observed at the beginning and end of each night's work.

These observations have all been completely reduced. An ephemeris based on Souillart's theory was computed, and the calculation of the tabular distances and position angles for the times of observations is just completed. The coefficients of unknown corrections to the constants of the theory are now being computed, and the complete equations of condition will soon be ready for solution.

With the astrographic telescope the following work has been accomplished :—

	No. of Plates.	No. of Exposures.	Duration of each Exposure.
			m m m
Triple exposure chart plates passed ...	57	171	30, 30, 30
„ „ „ rejected...	23	69	30, 30, 30
Revision Catalogue plates passed ...	200	600	6, 3, 20
Great Comet	17	...	various
Sundry	5	...	„

In addition to these, forty-six plates of long exposure (30^m to 45^m) in search for an ultra-Neptunian planet, have been taken in accordance with a request from Herr Hans E. Lau, of Copenhagen. The examination of the plates is not yet completed.

At the request of Dr. Backlund contact glass positives of the comet plates have been sent to Pulkowa.

During the year 159 catalogue plates, containing 100,203 stars, have been measured in both coordinates in each of two reversed positions of the plate ; all the standard stars have been measured by each of the two observers in both positions of the plate. When either coordinate of any star, as measured in one position of the plate, differs by $0''{\cdot}6$ from the corresponding coordinate resulting from the measure in the reversed position of the plate, the observations in both positions are repeated.

The total number of plates measured is now 397, containing in all 220,238 stars, an average of 555 stars per plate.

The geodetic arc of meridian has been carried to the Zambesi. The country near the Zambesi Valley proved most difficult. The observing season is a very short one, as transport from Salisbury cannot be begun until the rains cease in March. In many places the grass is six feet in height, and the natives begin to burn it in July, when the smoke renders further observing impossible. In the past season's work progress was most seriously delayed by difficulty in procuring oxen for transport. As the result of some misunderstanding on the part of the officials at Salisbury the oxen and waggons selected for purchase by Mr. Simms in February were not secured, and apparently no other suitable animals could be found at Salisbury. Mr. Heatlie, one of the surveyors, was sent to Bulawayo to inspect

some oxen ; he fell ill of typhoid fever, and the survey party was deprived of his services for the season. It was not until the end of April that transport could be organised and a start be made from Baruka. The original plan was that the reconnaissance and beaconing parties should start some weeks in advance of the observing party, but this was impossible because of delay in transport equipment ; and, owing to Mr. Heatlie's illness, both the reconnaissance and beaconing fell entirely on Mr. Antrobus. Heavy clearing work had to be done in many places, and progress in reconnaissance and beaconing could not be made to keep pace with the observing. At the more northern stations first the waggons and then carts had to be abandoned and all transport be done by native carriers. As the result of these delays, two, perhaps three, of the stations south of the Zambesi will require yet to be occupied with the geodetic theodolite. In the interval between the work of the two last seasons the wires used in measuring the base near Salisbury were recompared at the Royal Observatory, the measurement of the angles from the base to the main triangulation was completed, and signals were exchanged for longitude of Salisbury, Mr. Simms's personal equation being determined at the Cape before and after the longitude observations.

The operations northwards from the Zambesi will involve an entirely new departure. Observers and supplies will have to be landed at Chinde and be brought up the Zambesi beyond Zumbo, where transport by native carriers would be organised.

The operations of the Anglo-German boundary survey are in steady progress.

The field work of the triangulation has practically been completed, and Major Laffan with Lieutenant Doering are engaged in beaconing the boundary from Reitfontein southwards to the Orange River. Meanwhile the computations of the northern part of the work are being completed, and advantage will be taken of the first favourable opportunity to beacon the remainder of the boundary, which in many places is so arid that it cannot be traversed except in seasons when there is an exceptionally abundant supply of wild melons, as no natural water supply, other than the juice of these melons, exists.

The printing of the re-reduction of Bailey's survey has been at last completed, and the volume is ready for distribution.

The meteorological observations made during 1900 have been communicated to the Cape Meteorological Commission.

Since November 1 an hourly signal has been supplied to the General Post Office at Cape Town, whence by a relay the signal is transmitted along a special line by which the station clocks on the Wynberg line are automatically regulated. The ordinary time signals throughout the colony and the regulation of chronometers for His Majesty's ships have been continued as usual.

Mr. Goatcher, formerly assistant to Mr. Newall at Cambridge, joined the Observatory staff on December 17.

Mr. Hough, chief assistant, has been absent on leave in England since September 11.

Mr. Bryan Cookson, having completed a post-graduate course of study at Cambridge, came to the observatory in 1901 March in order to study practical astronomy.

Royal Observatory, Edinburgh.

No change has been made in the arrangements for carrying on the time service for the cities of Edinburgh and Dundee, standard time being supplied as in former years from the Molyneux mean-time clock of this Observatory. During four days in June the time-gun was not fired, the gun being then under repair. On two other days in the year there was also no gun signal, owing to temporary derangement of the mechanism. On one day in November the time-ball was not raised on account of the violence of the wind. With these exceptions, the time service has worked satisfactorily.

Much time has been devoted to observation of the new star discovered in the constellation *Perseus* by Dr. T. D. Anderson, of this city, on February 21, at $14^h\ 40^m$ Greenwich mean time. The star, at the time of discovery, was of the 2·7 magnitude, and shone with a bluish white light. At $6^h\ 58^m$ G.M.T. Dr. Copeland estimated the *Nova* as 0·3 magnitude brighter than *a Tauri*, and at $8^h\ 10^m$ considered it equal to *Procyon*, which it closely resembled in colour. Most of the observations of the *Nova* are now reduced, and ready for publication. Two preliminary papers were read before the Royal Society of Edinburgh describing the results of the earlier observations of the spectrum and light fluctuations.

A note "On the Theory of Temporary Stars" has been published in *Nature*, No. 1654, July 11, and in *Astronomische Nachrichten*, No. 3730, July 18, by Dr. Halm, in which the broadening and the multiple character of the bright lines are explained by rotational motions of gaseous matter round an incandescent body.

In the summer Dr. Halm undertook a series of observations for determining the rotation of the Sun by the spectroscopic method first applied by Professor Dunér. The apparatus designed by him differs from that used by Professor Dunér in the employment of a heliometer for throwing the light from the two opposite solar limbs upon neighbouring parts of the slit. The observations hitherto obtained seem to indicate the great accuracy of the method. They confirm, so far, the results obtained by Professor Dunér with regard to the peculiar law of rotation of the Sun's photosphere. It is Dr. Halm's intention to continue the observations for several years, in order to ascertain, if possible,

any changes which the law of rotation may undergo during a cycle of solar activity. Dr. Halm has read two papers before the Royal Society of Edinburgh on subjects connected with his theoretical solar investigations, and has contributed three other papers to the *Astronomische Nachrichten.*

The reduction of the meridian observations made between 1834 and 1845 has been continued by Dr. Halm, assisted by the temporary computer, Mr. Henderson. The Catalogue for 1840 is now finally compiled, and the computations of the new values for the precessions nearly completed. Some time will still be required for the comparison of the star places with other catalogues. The new places for those stars which are contained in the *Fundamental Catalog der Astronomischen Gesellschaft* have been forwarded to Professor Auwers, of Berlin.

Throughout the year the Troughton and Simms' meridian circle has been under the charge of Mr. Clark. Observations of Sir David Gill's zodiacal stars have been continued as far as practicable, though the requirements of other pressing duties have interfered to some extent with the work, and the number of observations made is consequently much less than usual. The instrumental errors have been determined at frequent intervals, and have been found to be quite as satisfactory as in previous years. Every opportunity has also been taken of determining the corrections to the standard clock used for the time service of the Observatory and the city. In addition to the ordinary "outside air" and "attached" thermometers, an "aspiration" thermometer by Fuess has been used in all the meridian observations made during the year. This instrument has been suspended alternately at the north end and at the south end of the Transit House, and has been read as a wet and dry bulb in conjunction with the ordinary thermometers. It is confidently expected that in the reduction of the observations for refraction greater accuracy will thereby be obtained.

The Milne seismograph, erected 1900 December, has been in continuous operation throughout the year with most satisfactory results. The records up to December 31 have been forwarded to Professor Milne, Secretary to the Seismological Committee of the British Association. Within the year seismograms of fifty-six undoubted earthquakes were found on the photographic rolls. Of these, all except one had semi-amplitudes measured on the paper varying from a quarter of a millimètre to 5·5 mm. Assuming the motion of the boom to correspond to the actual tilt of the supporting pillar, these semi-amplitudes would be equivalent to tilts of the pillar out of the vertical through angles varying from 0·18 to 3·98 seconds of arc. The exception occurred on August 9, when a semi-amplitude of 8·5 mm. was shown on the photographic roll, equivalent, on the above assumption, to a tilt of 6·08 seconds out of the vertical. This was one of a series of four earthquakes, all of considerable amplitude, recorded between 9^h 36^m A.M. of August 9, and 1^h 6^m P.M. of the 10th,

during which period the instrument was in a state of disturbance for over twelve hours. Observation of the bifilar pendulums was discontinued in July, it being considered unnecessary to keep them working any longer, since the installation of the Milne seismograph had proved so satisfactory. It has been thought advisable, however, to start one bifilar pendulum afresh to be observed in conjunction with the Milne seismograph.

The meteorological observations have been carried on by the staff of the Observatory as in former years, and a monthly copy of all the readings has been supplied to the secretary of the Scottish Meteorological Society for the use of the Registrar-General for Scotland, the monthly means being published in the Registrar's Quarterly Returns. A copy of the temperature and rainfall readings for each week has also been furnished to the Registrar-General at his request. The Robinson anemometer and King's barograph have also been kept in operation without interruption, and the weekly readings of the rock thermometers at Calton Hill have been continued. A paper on the observations of these thermometers was read before the Royal Society of Edinburgh in February by Mr. Heath, and has been published in vol. xl. of the *Transactions* of the Society. The paper contains tables of the readings of the thermometers from May 1888 to December 1899, with their monthly, quarterly, and annual means, also a *résumé* of the whole series of observations since the erection of the first set of thermometers in 1837, and a deduction of the annual curves therefrom. The reduction of the Robinson anemometer curves from the date of the erection of the instrument on Blackford Hill has been completed by Mr. Clark.

The 24-inch mirror of the Grubb equatorial and one of the 18-inch siderostat mirrors were successfully re-silvered in November.

A short note on the total solar eclipse of 1900 May 28 was read before the Royal Society of Edinburgh by Mr. Heath, and is published, with reproductions of four photographs of the corona, in vol. xxiii. of the *Proceedings*.

Cambridge Observatory.

Meridian Circle.—During the year 1901 the meridian circle has been used for observation on 101 nights, and frequently during the day for observations of *Polaris* and other standard stars.

The observation of stars comprised in Sir David Gill's catalogue of 2798 zodiacal stars has been continued during the year; 2669 complete observations have been taken and 935 observations of stars for clock error. Since the commencement of the observation of these stars in 1900 July, 1040 have been taken not less than three times, and the places calculated as far as apparent right ascension and apparent declination to 1901 December, and to mean equinox at the beginning of the year to 1901 March.

Daylight observations of *Nova Persei* and comparison stars were obtained on February 25, 28, March 1, 2, 3, 5, 7, 12, 21. On March 25 *Nova* was not visible at 3 P.M. in a perfectly clear sky ; cloudy days followed till April 1, when *Nova* was again visible on the meridian, the magnitude being estimated at $4\frac{1}{2}$. The resulting places were communicated to the Society in April (*Monthly Notices*, vol. lxi. p. 396).

Early in July three very faint circumpolar stars, together with a number of comparison stars, were observed for Dr. Stechert, of Hamburg. The resulting places, reduced to mean equinox at the beginning of the year, were communicated to him on August 31.

For instrumental deviation there have been made 78 observations of *Polaris* at the upper transit and 91 at the lower, and 61 observations of other close circumpolar stars. The observations of *Polaris* have also been utilised in making a fresh determination of the intervals of the wires.

The nadir point, level, and line of collimation have been regularly observed, and the constants for instrumental correction have been obtained from 312 equations.

At the request of Dr. Auwers a preliminary list of Cambridge transit observations made during the years 1847–1869 was communicated to him early in the year ; corrections to the clock-star places used in the reductions have been sent from Berlin, but owing to the pressure of other work the preparation of the catalogue reduced to epoch 1855·0 is not yet in progress.

Sheepshanks Photographic Equatorial.—At the date of the last Report the work on *Eros*, which had been in progress since 1900 October 1, was nearly concluded. Extremely bad weather had prevailed throughout January, and it was decided to make an end of the series at the end of the month. In all, 596 exposures had been made on the planet, of which about 350 are fit for measurement. In the four months' work, despite the bad weather, enough material had been collected to occupy for a long time the energies available for measurement and reduction ; to abstain for a while from making more photographs was therefore advisable. A temporary resumption of observation was necessitated by the appearance of *Nova Persei*, of which a number of plates for position and of series for photographic magnitude were secured. But the star soon passed beyond the hour-angles at which the telescope could reach it, and thenceforth to the end of the year observing was entirely suspended.

Much time was spent in developing a method of reduction of the *Eros* photographs by comparison with the tabular positions computed from two entirely separate heliocentric ephemerides of the Earth and of *Eros* expressed in rectangular coordinates. For the purposes of the experiment fifty exposures on two nights were measured and compared with special ephemerides very kindly computed for the purpose by Professor Millosevich. An account of the method, with the results of the preliminary

reductions, was communicated to the Society in November. Briefly it may be said that the results which the new telescope and measuring machine give are of a high order of accuracy, and that the method used seems to be so far promising as to deserve a more extended trial, which will be made.

When the *Eros* measures and reductions had got well under way it was time to resume observational work. The plane mirror has been re-silvered, the whole of the adjustments revised, and the instrument is now ready (18 Jan.) to begin work on a list of objects which may, it is hoped, have a sensible annual parallax. Only the very best nights will be given to this work; at present not much time can be spared from the solar parallax reductions.

Meteorological Observations.—The meteorological work has been continued on the same lines since 1899 July, when a change was made in the hours of recording barometer readings and temperatures. Weekly and monthly reports are communicated to the Meteorological Office. These include the records of hours of bright sunshine and of the rainfall.

The Newall Telescope, Cambridge Observatory.

The Newall telescope was used for observations on 91 nights in the course of the year 1901.

Throughout the year the instrument has been used in connection with the spectroscope. For the first two and a half months the four-prism spectroscope was employed in completing the material for the study of highly dispersed spectra of the brightest stars; it was also used in securing photographs of *Nova Persei*. Thirty photographs of the spectrum of the *Nova* were obtained between February 25 and March 10. The spectrum of *Capella* was photographed at certain epochs in its period, for which information is still needed for the better determination of the orbit. The spectrum of *α Persei* has been closely studied in continuation of observations communicated to the Society last year. The later observations (*Monthly Notices*, lxii. 124) show that neither of the periods suggested in the first communication will represent all the observations. The cause of the observed variation in velocity is not yet clear, and, in fact, the existence of it finds no support in the observations made at Potsdam and Mount Hamilton.

On March 11 the four-prism spectroscope was dismounted and taken to Sumatra for observations of the total eclipse of the Sun on May 17–18. A preliminary report on the observations made in Sumatra has been communicated to a joint meeting of the Royal Society and the Royal Astronomical Society (*Proc. Roy. Soc.*, vol. lxix. p. 209).

Arrangements had been made to fit a two-prism spectroscope to the equatorial, in place of the four-prism. The cast-iron box

for holding the prisms was fitted, and the instrument was adjusted in the latter part of March by Mr. A. W. Goatcher, and was steadily used throughout the rest of the year in the study of spectra of special faint stars—the *Nova Persei* included, up to November 2—and of planetary nebulæ.

A new annex has been added on the north side of the dome during the summer. It will be used as a laboratory for experimental work, which has been hitherto carried on under considerable difficulties arising from lack of space. The increased room thus obtained will, it is hoped, also give opportunities for students to take part in the work of the Observatory.

Mr. A. W. Goatcher, after nine years' work at the Observatory, was appointed to a post as computer at the Royal Observatory, Cape of Good Hope, and left Cambridge on November 23 for South Africa. Mr. H. J. Bellamy has been appointed assistant in his place.

Dunsink Observatory.

The meridian circle has been used throughout the year in the observation of the stars contained in Sir David Gill's list of 2798 zodiacal stars. The total number of these observations made since the last report is 7936. Of these 3550 observations were made of the right ascensions of the zodiacal stars and the same number of the declinations; 291 stars of the *Berliner Jahrbuch* were observed for determining the error of the Dent sidereal clock, and 268 declinations were taken for the equator point of the meridian circle; 69 determinations were made of the level error, 64 of the collimation, 62 stars of the *Berliner Jahrbuch* were observed for the error in azimuth, the nadir was determined on 64 occasions, and the error of runs on 18. The observations have been reduced to apparent place to 1901 January 31.

Photographic observations with the Roberts equatorial have been continued on the lines of former years. The South equatorial has only been used for occasional observations and by visitors on the monthly open nights.

The time service to Dublin has been continued as heretofore.

Durham Observatory.

The equipment has been completed and improved in many respects during the last year. A new sidereal clock by Kullberg has been going in a very nearly perfect manner. It is placed in the old observatory upon the stone pillar which, as in other old-fashioned places, runs through the building to support the equatorial. It is found that without special contrivance the range of temperature here is very small. In the month of

August a copy of Professor G. W. Hough's printing chronograph, made by an American firm, was delivered. Professor Hough, in the kindest manner, tested and altered the work until he could answer for its accuracy. This instrument, which works admirably, abolishes the labour of reading and transcribing the ordinary drum record, as it prints the observations plainly upon a paper tape. The accuracy of its records can be verified as often as may be thought necessary. It is used in conjunction with the Almucantar. A movable eyepiece and a wind-screen, both detached from the floating parts, have been added to the Almucantar, and in October, owing to some anomalies in its observations, the float and telescope were raised above the trough and some projecting studs removed from the bottom of the trough, as it was suspected that there was not always sufficient clearance between these and the float. When the telescope was replaced the anomalies disappeared, and since then the observations have fully come up to expectations : the instrument has been in use on all good nights in November and December. Mr. Chandler's arrangement of the reductions has been somewhat recast, and this has made it necessary to make a new computation book to facilitate reductions.

During the year Professor E. C. Pickering has kindly sent the complete MSS. of the photometric observation of *Jupiter's* satellites made at Harvard College Observatory. The number of these from 1878 to 1900 is 676, and the light curves of these have been charted, and are now ready for discussion. This work was made much easier byfacilities which Dr. Downing kindly granted to Mr. Carpenter for copying arguments and other quantities required from the *Nautical Almanac* computation books.

Meteorological observations have been continued as heretofore.

Glasgow Observatory.

Micrometric and transit observations for the determination of the constant of aberration and the motion of the pole were made with the transit circle during nine months of the year, in continuation of the work begun in 1897. Twenty-six nights were devoted to it, but only on eighteen nights more than one complete set of measurements of the faint star B.D. 89°·37, which is used as standard star, could be obtained. The reductions are up to date.

The large one-prism spectrograph, which is mounted on the 20-inch Breadalbane reflector, was used, with the exception of four nights, for photographing the spectrum of *Nova Persei.* Twenty satisfactory plates were secured, seven in March and April, and thirteen from August 1 to November 13, after which date it was not once sufficiently long clear, till the end of the year. On the first plate, taken on March 3, the spectrum extends almost as far as the D lines. Time observations were

taken on 110 nights, and the meteorological work has been carried on as in former years.

The Liverpool Observatory, Bidston.

No alteration or increase has been made in the instruments in use at this Observatory during the past year, and the purposes for which the Observatory was founded have been steadily and systematically pursued. These objects embrace the distribution of time signals, the examination of chronometers, and other philosophical apparatus, enquiries into the climate of the locality and the prosecution of such astronomical observations as the optical means permit. To take these in order it may be said there has been no failure of the time gun during the year, and the accuracy with which it has been fired is quite satisfactory. The number of chronometers, sextants, &c., deposited for test during the year is rather greater than usual; but considering the apparatus provided by the Board for this purpose, the general result is distinctly disappointing. The Richard thermograph, mentioned in the last report, and which is mounted in a Stevenson screen on the southern side of the building, has confirmed the Director's suspicions that the record of temperature in the past has generally been too high. The thermometric readings now made on the northern side seem trustworthy.

The observation of stars near the Pole, recommended by Professor Auwers, has been discontinued. Small but rapid changes in the azimuthal error, over which no sufficient control could be maintained, injured the results and would probably render them useless. The level error is not subject to the same kind of fluctuation. The equatorial has been used for comet observations, and also for double stars. Slight repairs are made to this instrument from time to time, and it is kept in a state of efficiency.

The earthquake observations, mentioned in the last report, have been continued throughout the year with a Milne seismograph for the regulation of unfelt tremors. This Observatory took part in connection with some others in an enquiry as to the effect of geological structure in influencing the record. The results have been communicated to Professor J. Milne, F.R.S., who has reported on them to the Earthquake Committee of the British Association. The attempts at observation with the bifilar pendulum have been definitely abandoned. There appeared to be no connection between the observed displacements of the two instruments, and it seemed not unlikely that an accumulation of rust on the iron rods sunk beneath the surface of the cellar, and which supported the pendulums, obscured the record and introduced irregular motions.

Radcliffe Observatory, Oxford.

During the year the work of bringing up the arrears of reduction, referred to in last year's report, has been pushed on steadily. With this object in view systematic observation with the transit circle has been discontinued during the greater part of the year, and the energy of the staff largely directed to this work, which is now in a more satisfactory condition.

All observations of right ascension have been reduced to mean place for the beginning of the year of observation as far as the end of 1898, and the reductions of the observations taken in 1899 and 1900 are in a forward condition.

The zenith distances have been completely reduced to mean place as far as 1899 February 22. The reduction of zenith distances observed from that date till the end of 1901 is well in hand.

During the year the printing of the forty-eighth volume of the Radcliffe Observations has been completed, and copies have been distributed as usual. This volume contains the meteorological results obtained at this Observatory from 1892 to 1899 inclusive. In the next volume, which, it is hoped, may be in the printers' hands before the date of the next report, will be included all the astronomical results obtained since 1892.

No further progress has been possible in the reduction of the old quadrant and transit observations made between 1774 and 1838, the Director's application for a grant for this purpose having been again postponed by the Government Grant Committee of the Royal Society. The importance of these observations seems to be generally appreciated, and the Director continues to receive from time to time letters from astronomers expressing the kindest interest in the undertaking and hopes of its successful accomplishment.

The transit circle has been employed chiefly for observing time stars. The position of *Nova Persei* was determined on seven days, viz. February 25, 28, March 1, 5, and December 11, 16, and 27. On December 9 systematic observations of working-list stars, consisting chiefly of stars between 85° and 90° N.P.D., were recommenced.

The new recording micrometer, supplied by Mr. Simms for the transit circle, has on further trial proved very satisfactory, and shown itself to be a valuable acquisition.

The Barclay equatorial telescope has been used chiefly for observations of *Nova Persei*, and a long series of observations of its brightness has been secured, extending from within three days of the time of its discovery to the end of the year. The results of these observations up to November 1 have been communicated to the Society and published in five papers in the *Monthly Notices* for March, April, May, June, and November. Some photometric measures of this star were obtained, soon after

its discovery, with a wedge photometer kindly lent by Sir Howard Grubb, and a few spectroscopic observations were made.

A special watch for *Leonids* was kept at this observatory on the night of November 14–15, the results of which have been already communicated to the Society.

Meteorological observations and automatic registrations have been maintained as usual throughout the year. Observations of underground temperature by means of platinum-resistance thermometers have been carried on uninterruptedly. The mercury-contact switch-board, for making connection between the resistance box and the several thermometers, was replaced on May 23 by one with copper contacts, which now seems to work very satisfactorily.

The mechanical parts of the large refracting telescope which, for the last three years, Sir Howard Grubb has been building for this Observatory are now complete, and the instrument is at present being dismantled, and the various parts are being packed for transport to Oxford. As reported last year, the 18-inch visual object-glass is finished, and the 24-inch photographic object-glass will probably be ready by the time the mechanical parts are erected. At Oxford progress has been made in the construction of the rising floor, the galleries, and the internal fittings of the dome. The framework on which the floor rests has been completed and hung on its counterpoises, and the work has been carried as far as it seems advisable to go before the heavier parts of the instrument have been mounted in position. The work of erecting the telescope at Oxford will be commenced forthwith.

During the year a very large expense has been incurred for repairs to the central tower, 100 feet in height, which constitutes such a striking feature of the Observatory building. The walls and ornamental projections of this tower, which was finished in 1795, had, like so many of the Oxford buildings, suffered severely from the weather, and had become in some places dangerous through the falling of pieces of stone. The greater part of the tower has been very thoroughly restored and the work is still in progress.

University Observatory, Oxford.

The main work of the year has been the measurement and reduction of plates for the Astrographic Catalogue, and two more zones have been completed, viz. zones $+28°$ and $+29°$, so that five out of the seven are now finished. The number of plates completed during the year 1901 is 151, bringing the total number up to 900 out of 1,180. It is hoped that the whole work may be finished within two more years.

In the early months of the year thirty further plates were taken of *Eros* and surrounding stars, and a large number of measures made. Acknowledgment should be made of the generous help of Mr. Frank Robbins, F.R.A.S., who has computed by

interpolation from the ephemeris of M. Millosevich 367 places of the planet at times corresponding to the exposures—a considerable volunteer undertaking.

Photographs of the region surrounding *Nova Persei* were taken on February 25 and following days, and a resulting survey of the region was communicated to the Society by Mr. Bellamy (*Monthly Notices*, vol. lxi. p. 340; see also p. 473). A similar survey of the region round the variable *RU Herculis* was made and published by him (*Monthly Notices*, lxii. p. 73).

Mr. H. C. Plummer, who was appointed second assistant at the Observatory last August, carried out an investigation of the systematic errors of measurements on photographic plates suggested by a paper recently published by M. Loewy; and found that the method of making measures in two positions of the plate differing by 180° in position angle (which originated, it is believed, at this Observatory) has an important and rather unexpected effect in the diminution of systematic error (*Monthly Notices*, vol. lxi. p. 618).

A comparison of Dr. Küstner's meridian observations with the Oxford photographic measures was made, and his (practically insensible) magnitude equation deduced, the results satisfactorily confirming his own results obtained by the "screen" method (*Monthly Notices*, vol. lxii. p. 3).

During the past year the Director carried out and published an investigation of the formulæ and tables convenient for comparing two overlapping plates (*Monthly Notices*, vol. lxi. p. 422). He also published a note on the rotation of a siderostat field (*Monthly Notices*, vol. lxi. p. 122) and another on a suggested method of conducting a terrestrial survey photographically (*Monthly Notices*, vol. lxii. p. 126). In connection with eclipse work he has made further measures of coronal brightness from photographs, but some anomalous results in the photographs of standard squares have delayed publication. He has also undertaken to edit the valuable observations of variable stars made during the last fifteen years at the Rousdon Observatory under the direction of the late Sir Cuthbert Peek, and the work of reduction (in the course of which several points of interest have arisen) is well advanced.

Mr. H. F. Mullis resigned his position as second assistant at this Observatory last July to take up an appointment at the Cape Observatory.

Temple Observatory, Rugby.

The same work as that of past years has been continued, the early portion of each evening having been given up to attempts to interest members of the school, most of whom come for the purpose of looking through a telescope only. Some have, however, attended as a class at fixed times. Mr. Lempfert and Mr.

Seabroke have continued measuring double stars, and the measures of the last five years have been prepared for publication by the Society.

Stonyhurst College Observatory.

The solar surface has been observed on 235 days, and the results are recorded by 144 drawings of spots and faculæ and 91 blank sheets. The mean spotted disc area deduced from these is 0·29,* against 0·55 of last year; and the mean daily range of the magnetic declination is 9′·1, against 9′·7 of the preceding year.

The experiments with a small prismatic camera mentioned in last year's report were complete just before the appearance of the new star in *Perseus*. A detailed description of the instrument is given in the January number of the *Monthly Notices*, in the introduction to a paper on the spectrum of *Nova Persei*, 1901. Eighty-six photographs of this spectrum have been obtained: half of these were taken between February 28 and April 26, and the other half between August 24 and December 20. Several attempts were made in May, which failed through the loss of light at the low altitude of the star.

In the intervening summer months the camera was employed on *Arcturus* and *α Cygni* for the construction of its wave-length curve, and on *β Lyræ* and *γ Cassiopeiæ* for the extension of their spectra into the shorter wave lengths.

The visual spectrum of the *Nova* was observed on 15 nights in March and April.

Markree Observatory. (*Col. E. H. Cooper's.*)

During the year this Observatory has been under the charge of Mr. F. W. Henkel, B.A., as previously, and of Mr. J. R. Armstrong in his absence.

The regular meteorological observations of a station of the second order have been continuously carried on and reduced as usual, weekly and monthly returns of barometer, temperature, sunshine, rainfall, wind and cloud, &c., having been sent to the Meteorological Office at London, weekly reports to the Registrar-General at Dublin, summaries of rainfall to Dr. Mill and Mr. Wallis at Camden Square, and to the local newspapers. Some magnetic observations have also been made. Determinations of local time with the transit circle with the instrumental corrections, &c., have been regularly made, also some observations for confirmation of the longitude of this Observatory by the method of "lunar culminations."

A few lectures were delivered in the month of February.

* The unit being $\frac{1}{5000}$ of the visible disc.

The Leonid meteors were scarcely seen here, though the weather was finer than is usually the case in November. The total rainfall for 1901 was 44·85 inches, or $3\frac{1}{2}$ inches above the average.

Mr. Crossley's Observatory, Bermerside, Halifax.

There has been no change in the routine work of this Observatory since the last report. The observations of *Jupiter* and *Mars* made during the year 1901 and the measures of double stars made since 1890 have already appeared in the *Monthly Notices.*

Wolsingham Observatory. (*Rev. T. E. Espin's.*)

During the year the measurement of double stars between +30° and +60° has been continued. The total number of nights on which observations have been secured is seventy-six, the number of measures 2289, and the number of stars 349 : of these seventy-two are new, and the mean measures of the new stars have been forwarded to the *Astronomische Nachrichten.*

Sir William Huggins's Observatory, Upper Tulse Hill.

The photography of the spectra of stars and of nebulæ which has been in progress for some years has been continued during the past year.

Experiments in the laboratory in connection with the Observatory work are also in progress.

Rousdon Observatory, Lyme Regis, Devon.
(*C. Grover, Observer-in-Charge.*)

The building and equipment of this Observatory have been maintained in their usual order. Weather has been generally favourable for astronomical work, and observations have been made on 171 nights, which is about the average number. The 6·4-inch Merz equatorial has been kept at the regular observations of long-period variable stars ; 572 magnitude determinations have been made ; March and October were the two most favourable months for observation ; Argelander's method was followed, as during the previous fifteen years. At each observation the light of the variable is estimated relatively to five comparison stars in the same field of view, the mean result being assumed to be the magnitude on the date of observation. Thus during the year 1901 about 3413 observations of stellar brightness have been made. Twenty-one maxima and seventeen minima have been recorded during the year. About twenty-five variables of long period are under regular observation, and these

being mostly circumpolar, the light variations are continuously recorded.

Transits are taken as often as required for rating the sidereal clock, which has now been in use for fourteen years, with a continually increasing accuracy as a timekeeper.

Considerable attention was given to the planet *Mars*, and between February 5 and March 21 eleven drawings were made, mostly with a power of 310. Many of the well-known features of the planet, as figured by Green and Knobel in the *Memoirs* of the R.A.S., were very well seen.

Dr. Isaac Roberts's Observatory, Crowborough Hill, Sussex.

The photography of nebulæ and star clusters has been carried on during the past year on the same plan as in preceding ones. Sir W. Herschel's list of fifty-two suspected nebulous regions, which Dr. Dreyer called attention to as deserving of photographic scrutiny, have now been observed in detail, and the results will be communicated in a special paper. A list of objects photographed in the course of the year is herewith appended on the same model as those in preceding reports.

List of the principal Photographs taken in 1901.

	R.A. h m	Decl. ° ′	Expos. h m
Neb. H II. 853 Andromedæ	0 5	+32 48	1 30
Neb. *h* 12 Piscium	0 10	+11 53	1 30
Neb. M. 31 Andromedæ	0 37	+40 43	1 30 (three)
Neb. H V. 20 Ceti	0 42	−21 18	1 30
Neb. H V. 19 Andromedæ	2 16	+41 54	1 30
Region of *Nova* Persei *	3 24	+43 34	1 30 (Sept. 15) 2 0 (Oct. 9)
H's Nebulous Region No. 13 ...	4 2	+25 11	1 30
Hind's variable nebula in Taurus ...	4 16	+19 17	1 35
Cl. of the *Hyades* in Taurus	4 24	+15 26	1 0
H's Nebulous Region Nos. 14 and 15	4 24	+35 8	1 30
„ „ „ No. 16 ...	4 26	− 7 30	1 30
„ „ „ „ 17 ...	4 29	+20 50	1 30
Cl. H VIII. 8 Tauri	4 40	+18 53	1 0
H's Nebulous Region No. 18 ...	4 44	+20 50	1 30
„ „ „ Nos. 20 and 21	5 17	+25 1	1 30
„ „ „ No. 22 ...	5 29	− 6 56	1 30
„ „ „ „ 23 ...	5 30	− 2 43	1 30

* Five minutes' exposures of the *Nova* were taken on March 3, 5, 6, 12, 24, 25, and April 4. On 1902 January 5 and 12 exposures were also obtained of $2^h\ 54^m$ and 90^m respectively.

	R.A. h m	Decl. ° ′	Expos. h m
Star magnitudes near ϵ Orionis ...	5 35	− 1 16	0 57
H's Nebulous Region No. 26	5 37	− 6 57	1 30
„ „ „ „ 27	5 43	+ 1 8	1 30
„ „ „ „ 30	6 40	+41 16	1 30
„ „ „ „ 32	9 36	+71 13	1 30
Neb. H I. 265 Ursæ Majoris	10 12	+58 42	1 30
H's Nebulous Region No. 33	10 12	− 9 3	1 30
„ „ „ „ 34	10 22	+51 32	1 30
„ „ „ „ 35	10 41	+62 45	1 30
„ „ „ „ 36	11 4	+62 44	1 30
Neb. H I. 224 Ursæ Majoris	11 13	+58 18	1 30
Neb. H I. 201 and II. 738 Ursæ Majoris	11 42	+48 42	1 30
Neb. H I. 202 Ursæ Majoris	11 48	+48 24	1 30
Neb. H I. 207 Ursæ Majoris	12 1	+48 2	1 30
H's Nebulous Region No. 37	12 2	+30 37	1 30
„ „ „ „ 38	12 12	+30 37	1 30
Star magnitudes near η Virginis ...	12 19	− 0 7	1 0 1 30
Neb. H I. 160 Virginis	12 30	− 3 14	1 30
Nebulous Region in Coma Ber. ...	12 54	+28 29	1 30
H's Nebulous Region No. 39	13 12	+34 8	1 30
Neb. H IV. 63 Ursæ Majoris	13 26	+58 56	2 0
Neb. H I. 187 Canum Venat.	13 52	+47 43	1 30
Cl. H VI. 40 Ophiuchi	16 27	−12 50	1 30
Neb. h 2002 Sagittarii	18 11	−19 50	1 30
Cl. M. 28 Sagittarii	18 18	−24 55	1 30
Star magnitudes near η Serpentis ...	18 20	− 2 55	0 30 1 0 1 30
Index Cat. 1287 Aquilæ	18 26	−10 52	1 30
Cl. H VI. 23 Sagittarii	18 27	−16 53	1 0
Index Cat. 1295 Aquilæ	18 49	− 8 55	1 30
N.G.C. 6764 Draconis	19 6	+50 46	1 30
Neb. H III. 743 Aquilæ	19 11	+ 6 21	1 30
Cl. H VI. 14 Vulpeculæ	19 26	+20 4	1 0
Neb. H III. 744 Aquilæ	19 37	−10 33	1 30
Index Cat. 1307 Vulpeculæ	19 38	+27 15	1 30
N.G.C. 6822 Sagittarii	19 39	−15 0	1 30
N.G.C. 6827 Vulpeculæ	19 44	+20 58	1 30
Neb. H III. 144 Cygni	19 58	+33 15	1 30

	R.A. h m	Decl. ° ′	Expos. h m
Index Cat. 1312 Sagittæ	20 12	+17 43	1 30
Index Cat. 1318 Cygni	20 19	+39 57	1 30 (two)
N.G.C. 6914 Cygni	20 21	+42 9	1 30
Index Cat. 1329 Delphini	20 39	+15 14	1 30
Index Cat. 1344 Aquarii	20 56	−13 46	1 30
Index Cat. 1360 Equulei	21 6	+ 4 39	1 30
N.G.C. 7040 Equulei	21 8	+ 8 27	1 30
Index Cat. 1369 Cygni	21 9	+47 21	1 30
Index. Cat. 1378 Cephei	21 20	+55 0	1 30
Index Cat. 1392 Cygni	21 31	+34 57	1 30
Index Cat. 1396 Cephei...	21 36	+57 0	1 30 2 0
Neb. H III. 452 Aquarii	21 49	+ 2 28	1 30
Neb. H III. 692 Aquarii	21 55	−13 41	1 30
Neb. H II. 207 Pegasi	22 3	+30 52	1 30 2 0 2 50
N.G.C. 7226 Cephei	22 7	+54 55	1 30
Index Cat. 1434 Cephei	22 7	+52 20	1 0
N.G.C. 7293 Aquarii	22 24	−21 21	1 30 2 12
Index Cat. 1453 Aquarii	22 41	−13 58	1 30
Neb. H II. 212 Pegasi	22 55	+29 10	1 30
Neb. H II. 251 Pegasi...	22 55	+15 27	1 30
Neb. H II. 203 Pegasi	23 4	+17 48	1 30
Neb. H II. 706 Cassiopeiæ	23 9	+60 58	1 30
Neb. H II. 600 Andromedæ	23 17	+40 42	1 30 2 0
Neb. H II. 226 Pegasi	23 23	+21 52	1 30
Neb. H II. 208 Pegasi	23 39	+25 31	0 47 1 30
Neb. *h* 2266 Cassiopeiæ	23 40	+69 12	1 30
Neb. H II. 231 Pegasi	23 46	+19 33	1 30
Neb. H II. 227 Pegasi	23 59	+20 12	1 17
Neb. *h* 2302 Cassiopeiæ	23 59	+67 7	1 30

Mr. Saunder's Observatory, Crowthorne, Berks.

The principal work done at the telescope has been the completion of the micrometric measures of selenographic positions required for the reduction of photographic plates. In all nineteen points have been measured, each on not less than four nights,

and most of them under evening as well as under morning illumination.

An account of the use made of these measures has already been communicated to the Society, and appears on p. 41 of the November number of the *Monthly Notices*. Subsequent work upon another plate, for which Mr. Saunder is indebted to the generosity of the Director of the Paris Observatory, has shown that half of the 53 positions there given are sufficient for an accurate determination of the constants, and confirms his opinion that the preliminary difficulties of the investigation have been overcome.

On clear moonless nights the telescope has been used for comet sweeping.

Daramona Observatory.

In the early part of the year the weather was as bad as the end of the previous one, and no work could be done.

In May there was nearly a week of fine weather, and at the request of Professor G. Forbes a photographic search was commenced for his hypothetical ultra-Neptunian planet. As the field of the 24-inch reflector is so small a 6-inch portrait lens by Dallmeyer was used. This fine lens was kindly lent for the search by Sir David Salomons, Bart. A camera for it was bolted to the tube of the 24-inch reflector, and the star-images were found to be very small and sharp, except near the corners of the $8\frac{1}{2}$ inch by $6\frac{1}{2}$ inch plates which were used. The circular field was about 5° in diameter. One photograph was taken with an exposure of three hours, and two with ninety minutes each. The duplicate photographs for comparison will be taken during the coming spring.

The new pyrheliometer to be used with Callendar's electric recorder was received from the Instrument Company of Cambridge. It is mounted equatorially and driven by clock-work, and is intended to record the daily amount of solar radiation. It gives every promise of giving a valuable record.

Some further experiments were carried out in the laboratory on the effective solar temperature. The method was to balance the solar radiation with that from an absolutely "black body." The results obtained were published in the *Proceedings* of the Royal Society. The mean result comes out as 6590° C. Experiments were also made on the temperature of the crater of the electric arc, and its temperature came out as 3300° C., or just one half of that of the Sun.

Hong Kong Observatory (1900 *and* 1901).

Weather forecasts and storm warnings, and the other meteorological work, and the time-service were continued during 1900

and 1901 ; 7333 transits were observed in those two years, and it is estimated that the catalogue of R.A.'s of over 2000 southern stars will be ready for press early in 1904. About 400 micrometrical measurements of double stars, mostly southern pairs, were obtained. At Professor Pickering's request the sequences observed by Sir John Herschel at the Cape have been reduced again with photometric magnitudes from the Harvard College Observatory. An increase (above that obtained with the aid of the Uranometria Argentina) in the accuracy of the catalogue of magnitudes of stars over sixty years ago has been the result of the recalculation, and Professor Pickering intends to use Herschel's magnitudes, which are frequently as accurate as those resulting from the best modern work, in a revision of the Harvard Photometry. The recalculation of the orbits of double stars has been continued, and a new orbit of η *Cassiopeiæ* has been published in the *Astronomische Nachrichten*. *Nova Persei* was regularly observed last spring.

Kodaikanal Observatory.

During the past year the work on the buildings has made considerable progress and the main buildings have been nearly completed. Regular observations on the Sun were begun early in the year. On every day on which the Sun is visible it is examined for spots and faculæ, and the positions of any found are determined approximately by projection. Drawings are made of all important groups, and photographs are taken whenever it seems of importance.

Spectroscopic work could not be begun fully till some time later, but since September the large spectrograph has been in full working order, and a number of spectrograms has been obtained. Under instructions recently received from the Observatories Committee of the Royal Society, eye observations of the spectra of sun-spots, prominences, and the chromosphere take the first place in the work of the Observatory. Hence the early hours of the forenoon, which are the best for work on the Sun, are mainly devoted to eye observations.

Several photographs were taken of the great comet, but the conditions were unfavourable and the results not very satisfactory. Preparations were made for fully observing the annular eclipse in November, but unfortunately the day was one of the worst in the whole year, and only a few brief glimpses of the Sun were obtained through thick drifting fog.

Complete meteorological observations have been taken throughout the year, and actinometrical observations have been taken on suitable days with a Balfour Stewart actinometer and with Buchanan's solar calorimeter. Records have also been obtained without any serious break with a Milne seismograph.

Though the year here, as elsewhere throughout India, has

been a very abnormal one from the meteorological standpoint, there were 2000 hours of bright sunshine. There were, however, twenty-seven days on which there was less than half an hour, and sixty-one days on which there was less than two hours of bright sunshine. Some progress has been made with the erection of an underground building for a magnetical observatory as one of the base stations for the magnetical survey of India. Plans and specifications have been sent home for a spectroheliograph and for a plane grating spectroscope.

Melbourne Observatory.

Meridian Observations made with the 8-inch Transit Circle.

	R.A.	N.P.D.
Azimuth stars	324	130
Clock „	656	...
List „	1151	1157

The list stars were selected from the Melbourne plates of the *Astrophotographic Catalogue* to be used as standard reference stars in the reduction of these plates.

The separate results and annual catalogue for the year 1900 have been prepared. The reductions of meridian observations made in 1901 are nearly up to date. The precessions for the whole number of stars, 3100, included in the third Melbourne ten-year catalogue now in course of preparation, have been independently recomputed. The total number of standard stars for the reduction of the catalogue plates, which have been observed at least three times with the 8-inch transit circle, is 3951.

Astrophotographic Operations.—

Chart plates with triple exposure (30^m each)	68
Chart plates with single exposure (60^m each)	17
Catalogue plates (duplicate series)	98
Test plates on South Polar region	42
Test plates on Oxford typical regions	12
Test plates for adjustment of centre, focus, trails, &c....	30
Plates for comet (*a*) 1901	9
Experimental plates for investigation of magnitudes ...	41

Nine triple-exposure chart plates, two single-exposure chart plates, and three catalogue plates of the above list were rejected as defective.

The state of this work to December 31st, 1901, is as follows:—

Chart plates with triple exposure passed as satisfactory	112
Chart plates with single exposure, complete	—
Catalogue plates, first series, complete	—
Catalogue plates, second series	76

Contact prints on glass were made of the complete series of chart plates with single exposure.

The time service, weather service, terrestrial magnetism, registration of tides, rating of chronometers for the shipping, testing of meteorological and surveying instruments, and a multitude of other duties for public local requirements were carried on as usual. The reduction of arrears of magnetic records and measurement of cloud photographs have been continued by the temporary staff of computers, and are well advanced.

The Great Telescope, 8-inch equatorial, and photo-heliograph have been used only for few occasional observations and for visitors.

This comparatively narrow limit of astronomical activity at this Observatory is the unavoidable consequence of conditions which have been explained on previous occasions, and which still exist—viz. the demands made on our time by public local requirements, the clearing up of arrear records, and the grievous circumstance that no appointment has yet been made to fill the position of Chief Assistant, which has been vacant since 1895. Moreover, protracted illness of several members of the staff has very greatly interfered with the work of the year.

Sydney Observatory.

The staff of Sydney Observatory has not been changed during the year, and the work of observing the reference stars for the astrographic plates is progressing steadily. During the year the following observations have been made by Messrs. Lenehan and Raymond :—

	R.A.	N.P.D.
Clock stars	531	391 stars
Azimuth stars	171	171 „
Reference stars for plates ...	1801	1803 „
	2503	2365 „

State of Computations :—

For 1900 star constants and corrections almost completed.

„ 1901 star constants and corrections are now being checked.

„ 1901 stars observed are now being computed.

The above and previous years make 2639 stars ready as Reference stars for the astrographic photographs.

Photographic Branch.—Work has been carried on steadily. There has been little rain, but the prevailing dust and smoke

and cloud has materially hindered the work. Red Hill keeps its reputation as a good place for photography.

Star Photographs in 1901.—The photographic work has been carried on as usual; 187 chart plates were obtained, and considerable time was devoted to the comet, but a hazy sky after sunset made it impossible to get a good photograph, the photographic fog rendering the picture of the comet of no use.

Owing to the hindrances in making a new form of measuring machine considerable delay has been inevitable, but the machine at Sydney is now completed, and is ready for use in measuring star plates.

The ordinary *screw* used for small measures has been discarded, and a steel band wound up by a screw controls the micrometer slides.

The quantity measured is presented to a microscope and read off in minutes of arc, seconds and tenths of seconds, with means of estimating 0″·10. Description and photographs of the machine will be sent as soon as possible.

Measurement of the Sydney and Melbourne Plates of the Astrophotographic Catalogue. Joint Report for Sydney and Melbourne.

This work was carried on by the Measuring Bureau at the Melbourne Observatory, using the Repsold micrometer designed by Sir David Gill, and the Melbourne filar micrometers referred to in previous reports. The second Gill micrometer, which was ordered from the Repsolds as far back as May 1900, has not yet reached Melbourne, and the new machine designed by the Government Astronomer of New South Wales has not yet been placed in the hands of the bureau, in consequence of which the work has not proceeded at its full speed.

The measurements made during the year are as follows:—

One hundred and one Sydney plates, containing 71,223 stars completely measured in the direct and reverse position.

Eleven Melbourne plates, containing 4939 stars, also completely measured in the two positions.

Total number of plates measured up to December 31st, 1901:—

Sydney plates, 141; containing 106,919 stars.

Melbourne plates, 99; containing 24,494 stars.

Measures differing by less than 0″·6 in the direct and reverse position are passed as satisfactory.

The number of discrepancies greater than 0″·6 rarely exceeds 3 per cent., which is considered a fair indication of the efficiency of the measures. Arrangements are now being made for commencing the publication of the work. The method of deter-

mining photographic magnitudes will form the subject of a separate paper by the Government Astronomer for Victoria.

Perth Observatory, Western Australia.

Astrograph.—A start has at last been made in systematic astronomical work. By invitation of the International Committee this Observatory has taken zone $-32°$ to $-40°$ in connection with the Photographic Chart and Catalogue of the heavens. From a variety of causes it was not until the latter part of the year that a real commencement could be made, and even now the percentage of rejected negatives is high. This is due mainly to the difficulty of securing reliable plates. A few blemishes or a certain amount of fogginess do not necessarily cause the rejection of a Catalogue negative, but it is felt that if the chart plates are ever to be reproduced they must have clean glass free from fog or impurities in the film, and we have so far experienced great difficulty in obtaining this result. The number of plates passed so far is sixteen for Chart and twenty-four for Catalogue. The former set contains three images of each star situated at the points of an equilateral triangle, with half an hour's exposure for each. It is not proposed to take any with long single exposures.

Measurement of Plates.—No arrangements have yet been made for this, but it is hoped that the Government will shortly authorise the appointment of two ladies, who will undertake the measurements with a machine of the form designed by Professor Turner.

Transit Circle.—A working list of three stars per degree, or twelve per plate, has been prepared with the aid of the Cape Durchmusterung, and this will form the principal work for the transit observers. Each star will be observed three times, and we hope to complete a zone of two degrees per year. The work was commenced on 1901 October 6, and by the end of the year we had obtained 1072 observations of zone stars, including the necessary three determinations for 258 stars.

The level and azimuth error and nadir reading are always observed at the commencement and end of each evening's work, and the circle is read by four microscopes.

Time Service.—In addition to the zone observations 1052 clock stars were taken for clock error, and instrumental constants were determined as follows :

Level	267
Azimuth	316
Collimation	74
Nadir Point	34

The time ball at Fremantle is dropped daily at 1 P.M. W.A.

standard time, including Sundays and holidays, and at such other hours as may be requested by the commanders of mail-boats.

There were six failures during the year—three being caused by a fault on the line, one by a heavy rainfall finding its way into the electrical machinery, one of the batteries running down, and one due to some undiscovered cause. The control of the telegraph and railway clocks worked satisfactorily throughout the year.

Meteorological.—A book on the climate of Western Australia, containing the results of past observations, and entailing a considerable amount of work, has at last been printed and is now being distributed. The preparation of this and passing it through the press has delayed the publication of the annual report for 1900, which, however, will shortly be available.

Great attention has been bestowed, as usual, on current work, and most of the stations south of the tropics were inspected by an officer from the Observatory at some time during the year.

The daily weather forecasts, which are generally looked upon by the public as the sole reason for the existence of an Observatory, have again been very successful. There are five distinct series of these, viz. : (1) and (2) general forecasts for the whole State, issued at noon and at 8 P.M. respectively ; (3) and (4) special for the goldfields, issued as above ; (5) special forecast for Perth, issued at 9 A.M.

The following were the percentage results for 1901 :—

	1	2	3	4
Correct	93	90	91	90
Partially correct ...	6	9	8	8
Wrong	1	1	1	2

The results of No. 5 were not tabulated, but the forecasts were almost invariably correct.

Miscellaneous.—A re-determination of the difference of the longitude between Perth and Adelaide was made in the autumn. Signals were exchanged on five nights, and the resulting longitude of the Perth Observatory is—

$$7^h \quad 43^m \quad 21^s{\cdot}97,$$

as compared with $7^h\ 43^m\ 21^s{\cdot}74$ previously obtained. A difference of this magnitude is hard to explain, although it is not large compared with results obtained in other places. At present the older value has been adopted.

A class of instruction for pupil surveyors in practical astronomy was conducted by the Government Astronomer in July and August, of which four candidates availed themselves.

A good series of observations of the Great Southern Comet (1901, I.) was obtained with the astrograph, the results of which have already appeared in the *Monthly Notices.*

New Instruments.—A Milne seismograph was mounted on September 30 in the basement of the dome building, and has been working satisfactorily.

Lovedale Private Observatory. (*Dr. Alex. W. Roberts's.*)

The work of this Observatory during 1901 has been the same as in previous years, viz. the observation of variable stars south of −30° declination.

One hundred stars were under regular observation during the year, the detailed work being as follows :—

	Stars.	Observations.
Algol variables	7	325
Rapid variables	2	371
Short-period variables	22	1740
Long-period variables	69	3609
Total	100	6045

Several of the Algol variables were observed with the new prismatic telescope. In this case each observation is the mean of six pointings, the field being rotated through 60° each pointing. The mean relative magnitudes thus obtained are freed from positive error.

It is hoped that these determinations will be of some service in arriving at orbital elements of the Algol stars under observation.

All short-period variables are observed twice, once direct and then with the field inverted. In this case each observation is the mean of two determinations.

The fainter stars are observed with the $3\frac{1}{4}$-inch Ross telescope, but it is a matter of regret to me that I am unable to follow faint stars below $11^{m}{\cdot}2$, the limit of the Ross glass. The form of the light curve of a star at its minimum phase is as important as the light curve during the star's maximum.

At the beginning of the year a preliminary paper on the elements of 95 southern variable stars was given in the *Astronomical Journal*, Nos. 491 and 492. A fuller consideration of the observations made at Lovedale, now extending over ten years, will be undertaken when a full series of measures with the new prismatic telescope has been secured.

Mr. Tebbutt's Observatory, The Peninsula, Windsor, N.S. Wales.

The following is a statement of the work at this Observatory during the year 1901 :—

Meridian Department.—

Nights on which the time was determined		106
Observations of stars with a declination not exceeding −40°...		479
Observations of stars in high declination for azimuth		109
Separate determinations of	level error	288
	collimation error	27
	azimuth error	78

The year was throughout a dry one, and as a consequence the disturbances of the level error were small.

Extra-meridian Department.—The following micrometer comparisons were made with the equatorials :—

	Nights of Observation.	Number of Comparisons.	Number of Comparison Stars.
Venus	4	54	3
(1) Ceres	6	60	2
(11) Parthenope	9	114	5
(18) Melpomene	10	136	5
(78) Diana	4	47	2
Comet I. 1901	32	273	39

In addition to the above work twenty-eight southern double stars were measured, and a few occultations of stars by the Moon were observed. The usual meteorological observations were also taken.

Notes on some Points connected with the Progress of Astronomy during the Past Year.

Discovery of Minor Planets in 1901.

Thirty-six new planets were discovered during the past year, as follows :—

Provisional Designation.	Permanent Number.	Name.	Date of Discovery, 1901.	Discoverer.	Place of Discovery.
FV	464	...	Jan. 9	Wolf	Heidelberg
FW	465	...	,, 13	,,	,,
FX	466	...	,, 17	,,	,,
FY	467	...	,, 18	,,	,,
FZ	468	...	,, 18	,,	,,
GB	469	...	Feb. 15	,,	,,
GC	473	...	,, 17	,,	,,
GD	474	...	,, 17	,,	,,
GE	...	...	,, 20	Carnera	,,
GF	...	...	,, 22	Wolf	,,
GG	...	...	,, 22	,,	,,
GJ	470	Kilia	Apr. 21	Carnera	,,
GK	...	...	,, 24	Wolf	,,
GL	...	...	May 21	Wolf, Carnera	,,
GM	...	...	,, 23	Wolf	,,
GN	471	...	June 7	,,	,,
GP	472	...	July 12	,,	,,
GQ	476	Hedwig	Aug. 17	,,	,,
GR	477	...	,, 23	,,	,,
GT	...	...	Sept. 19	Wolf	,,
GU	478	...	,, 21	Carnera	,,
GX	...	...	Oct. 11	Carnera, Kopff	,,
GY	...	...	,, 11	,,	,,
GZ	...	...	,, 13	Kopff	,,
HA	...	...	,, 13	Carnera, Kopff	,,
HB	...	...	,, 16	Kopff	,,
HC	...	...	Nov. 2	Wolf, Kopff	,,
HD	...	...	,, 5	,,	,,

Provisional Designation.	Permanent Number.	Name.	Date of Discovery, 1901.	Discoverer.	Place of Discovery.
HE	...	...	Nov. 3	Kopff	Heidelberg
HF	...	...	„ 6	Wolf	„
HH	...	...	„ 12	„	„
HJ	479	...	„ 12	Carnera	„
HK	...	...	„ 16	„	„
HL	...	...	Dec. 16	Wolf	„
HM	...	...	„ 5	Kopff	„
HN	475	...	Aug. 14	Stewart	Arequipa

To these should be added the following planet, discovered in 1900, but not announced till after the last Annual Report :—

GA	...	...	1900 June 28	Keeler	Lick

The planets provisionally designated GH, GS, GW, HG proved to be identical with 449 *Hamburga*, 453, 247 *Eukrate*, 455 *Bruchsalia* respectively. FT is not identical with (220) *Stephania*, as was conjectured last year. HK may be 367 *Amicitia*. GV is 202 *Chryseïs*.

Planets FT, FU, GA, GE, GF, GG, GK, GL, GM do not receive permanent numbers, not having been sufficiently observed. The announcement of the discovery of GO was cancelled as erroneous.

The following planets have been named :—

No.	Name.	No.	Name.	No.	Name.
356	Liguria.	381	Myrrha.	419	Aurelia.
358	Apollonia.	382	Dodona.	423	Diotima.
361	Bononia.	388	Charybdis.	424	Gratia.
362	Havnia.	389	Industria.	425	Cornelia.
363	Padua.	390	Alma.	432	Pythia.
364	Isara.	393	Lampetia.	435	Ella.
365	Cordoba.	397	Vienna.	436	Patricia.
367	Amicitia.	399	Persephone.	442	Eichsfeldia.
370	Modestia.	402	Chloe.	443	Photographica.
372	Palma.	403	Cyane.	446	Æternitas.
373	Melusina.	404	Arsinoe.	447	Valentine.
374	Burgundia.	405	Thia.	448	Natalie.
375	Ursula.	407	Arachne.	449	Hamburga.
376	Geometria.	408	Fama.	450	Brigitta.
377	Campania.	409	Aspasia.	451	Patientia.
378	Holmia.	415	Palatia.	454	Mathesis.
379	Huenna.	417	Suevia.	455	Bruchsalia.
380	Fiducia.	418	Alemannia.	457	Alleghenia.

The following planets have been observed at one opposition only : (99) *Dike*, (132) *Æthra*, (155) *Scylla*, (156) *Xanthippe*, (157) *Deianira*, (193) *Ambrosia*, (220) *Stephania*, (285) *Regina*, (290) *Bruna*, (293) *Brasilia*, (296) *Phaëtusa*, (309) *Fraternitas*, (310) *Margarita*, (315) *Constantia*.

From this point we omit the names and give number only : 316, 319, 320, 323, 327, 330, 341, 353, 355, 357, 359, 360, 368 383, 392, 393, 394, 395, 396, 398, 399, 400, 406, 408, 410, 411, 413, 414, 417, 421, 422, 426 to 431 (incl.), 436, 437, 438, 441, 448, 450, 452, 455. All the other planets from (1) to (456) inclusive have been observed at two or more oppositions.

We may note the rediscovery last year of the two interesting planets (361) *Bononia*, (401) *Ottilia*. The former has the greatest aphelion distance (viz. 4·74) of the whole family, while the mean motion of the latter (584″) is approximately double that of *Jupiter*.

The planet HN is interesting from its very high south declination ($61\frac{1}{2}°$) at discovery, also for its very large eccentricity (e=0·38) and its small perihelion distance (1·60). It was near perihelion when discovered, and will probably be altogether invisible at aphelion oppositions.

Dr. Bauschinger, Director of the Berlin Rechen-Institut, has published an interesting table of statistics of the minor planets discovered up to the end of 1900, which completes the first century of our knowledge of them. We give a summary of some of his results.

The ascending nodes show a decided tendency to cluster in the neighbourhood of the ascending node of *Jupiter's* orbit ; this is in satisfactory agreement with Newcomb's theoretical results.

Of the inclinations 315 are under 10°, 133 between 10° and 20°, 29 between 20° and 30°, 1 (*Pallas*) over 30°, 107 have the eccentric angle ϕ between 0° and 5°, 195 between 5° and 10°, 132 between 10° and 15°, 27 over 15°. There seems a slight tendency for great inclination and great eccentricity to go together, but no connection between eccentricity and mean distance is indicated.

The longitudes of perihelia show a well-marked maximum near the longitude of *Jupiter's* perihelion, and an equally well-marked minimum near the longitude of his aphelion.

The question is discussed whether this could arise from some months being more favourable than others for discovery, but Dr. Bauschinger finds that the phenomenon cannot be thus accounted for and must be real. The fact, however, that September is far the most fruitful month of discoveries receives an explanation ; for the rich region of perihelia souths near midnight ; in addition to this the weather is usually fine, the nights dark, and the altitude of the ecliptic at midnight considerable.

Newcomb had already deduced theoretically that the perihelia should be more numerous in the neighbourhood of *Jupiter's* perihelion.

Arranging the planets in order of mean daily motion the gaps near 900″ and 600″ (that is, three times and twice *Jupiter's* mean daily motion) are very strongly marked ; there are other less strongly marked gaps.

Dr. Bauschinger accordingly divides the family into three groups :

	Planets.
The *Mars* group with μ between 2015″ and 900″	108
The chief group „ „ 900 „ 600	337
The *Jupiter* group „ „ 600 „ 400	18

Then follows a discussion of the brightness and probable dimensions of the small planets. It is concluded that very few brighter than the 10th magnitude remain to be discovered, but the fainter ones show no signs of exhaustion.

The mean albedo is assumed 0·240, midway between that of *Mars* and *Mercury* ; *Mars* is assumed to be of magnitude −1·79 at mean opposition, and its semidiameter to be 4″·68 at unit distance. The following equation then gives the radius ρ of a planet in kilometres :

$$\log \rho = 3{\cdot}3135 + \log [a\,(a-1)] - \tfrac{1}{5}\, m_0.$$

A table of double entry is provided, with arguments log a and m_0, enabling the radius of a planet to be at once inferred.

It goes without saying that no stress can be laid on individual diameters deduced by this method, since we know by Professor Barnard's measures on the four brightest asteroids that their albedoes vary greatly.

We give the diameters and albedoes deduced by him, for comparison with the results of Dr. Bauschinger's formula :

	Diameter in miles.		Albedo.	
	Bauschinger.	Barnard.	Bauschinger.	Barnard.
Ceres	482	477	0·240	0·195
Pallas	364	304	„	0·257
Juno	182	120	„	0·488
Vesta	518	239	„	0·825

It will be seen that Dr. Bauschinger's diameters are on the whole considerably in excess of Professor Barnard's, and probably a higher albedo than that selected by the former would have given more reliable results. The mean of Barnard's albedoes is 0·44 ; if we adopt this as our standard albedo we must reduce all Bauschinger's diameters in the ratio $\sqrt{\frac{6}{11}}$ or 0·7386.

The formula for the diameter of a planet in miles using this albedo would be :

$$\log (\text{diam. in miles}) = 3{\cdot}2763 + \log [a\,(a-1)] - \tfrac{1}{5}\, m_0.$$

Bauschinger's diameter for *Eros* is 32 km., or 20 miles. It would be 15 miles, using the above formula.

The volume of the 12 largest planets (Nos. 1, 2, 3, 4, 7, 9, 10, 15, 16, 22, 29, 349) forms $\frac{2}{3}$ of the volume of the whole; and since the tiny planets now discovered add so little to the volume, Dr. Bauschinger estimates that the entire family (including those still to be discovered) would form a sphere of radius 660 km., or diameter 830 miles, which would become 610 miles, using the albedo 0·44. This is $\frac{1}{1\frac{1}{3}}$th of the Earth's diameter; and if we estimate the mean density as $\frac{2}{3}$ of the Earth's, the total mass would be $\frac{1}{3300}$ of the Earth's, or $\frac{1}{40}$ of the Moon's.

Such estimates are, however, apt to be fallacious, for there may be numerous planets of considerable relative mass near *Jupiter's* orbit, which are invisible owing to distance.

A. C. D. C.

The Planet Eros.

Observations of this planet for parallax were continued up till April last. There is reason to believe that active progress is being made with the measurement and reduction of the plates, but scarcely anything has yet been published.

Numerous meridian observations have been made of the reference stars, and M. Loewy has already published a preliminary catalogue, which, however, will not be definitely adopted till after the observations of the present season have been included.

The discovery of the variability of the planet in a period of $2^h\ 38^m$ was made by Herr E. von Oppolzer in February last, and confirmed by numerous observers; the range of variability seems to have been more than a magnitude. M. Ch. André considered that two consecutive waves of the variation were not exactly symmetrical, and consequently that the complete period should be taken as $5^h\ 16^m$. This result, while probable, can scarcely be considered as definitely established. There have been three theories to account for the variation :—

(1) That the planet is double, consisting of two bodies revolving almost in contact in a period of $5^h\ 16^m$. Mutual occultations take place when the plane of motion passes through the Earth.

(2) That it is shaped like a dumb-bell; the further suggestion is made that two spherical bodies may have collided and adhered together. Mutual occultations would take place as above when the Earth was in the plane of motion.

(3) That the variation is simply caused by large differences of albedo of various parts of its surface.

All of these hypotheses are open to objection, but it would seem that they exhaust the possible explanations. The fact that the large variation of light was temporary seems to favour (1) or

(2). There is evidence that the variation in 1901 January was much less than in February, and by May 8 it had sunk to zero, according to Professor Wendell, of Harvard Observatory. The Harvard photographs of former apparitions have been examined for variation in light. The range seems to have been very small at the time that the 1893–94 photographs were taken, but larger in 1896 June, when it seems to have been about 1 magnitude.

It is most desirable that accurate observations both of the position and brightness of the planet should be made at every apparition; the former in order to determine the perturbations by the Earth, which will in the course of years give a very reliable value of the solar parallax; the latter to determine the explanation of the light changes. At the next opposition the planet will be too far south for European observation; but observations will be possible next autumn, when the planet will be in perihelion, and consequently nearly as bright as at opposition. The following ephemeris is abbreviated from Harvard Circular No. 61.

Date.	R.A. h m	Decl. °	Mag. m
1902 Sept. 27	8 42	N. 25·0	12·45
Nov. 16	11 37	N. 2·3	12·09 perihelion
1903 Jan. 5	14 9	S. 21·7	12·07
Feb. 24	16 30	36·1	12·11
Apr. 15	18 5	43·1	11·79
June 4	17 14	43·5	11·55 nearest Earth
July 24	16 21	31·1	12·41
Sept. 12	17 17	S. 25·4	13·43

A. C. D. C.

The Comets of 1901.

Giacobini's comet, discovered on 1900 December 20, to which reference is made in the last report, and whose orbit seemed likely to prove interesting, has unfortunately been very little observed on account of its extreme faintness. Dr. Aitken observed the comet on February 15 with the 36-inch refractor of the Lick Observatory, but this is an isolated position, measures having generally ceased a month earlier. Dr. Kreutz's short-period ellipse represented the motion of the ellipse in February, but no farther enquiry into the orbit has been made.

The Great Comet appears to have been independently seen at several places in the southern hemisphere. At Paysandu it was reported as early as April 12, and certainly through the latter end of April onwards through May the comet was a most conspicuous object as it swept through the constellations of

Pisces, *Eridanus*, and *Orion*, moving nearly parallel to the equator. At the time of the earliest observations the comet was visible only in the morning sky, but after passing perihelion on April 24, it was visible in the evening and attracted considerable attention from the brilliancy of the nucleus and the shape of the tail. The former on May 2 rivalled *Sirius* in lustre, and was distinctly elliptical in shape. The tail has been described as triple, but it is difficult to reconcile that description with the photographs and drawings that have come to hand. The main tail was seen to be divided by a distinct rift, while a quantity of cometic matter near the nucleus varied greatly in brilliancy, suggesting another tail. Major Eddie, who made a study of the comet at Naauwpoort, gives a description of what he saw on May 4, which coincides very closely with the pictures that have arrived from the Cape of Good Hope. "The head was sharply defined on its western periphery, but its following portion was somewhat fuzzy and rugged. The principal tail was sharply defined on its northern border and had a central condensation, also a dark rift, which gave it a bifurcated appearance. The lateral tail was much dimmer and broader and seemed to proceed from behind the nucleus; the cometic matter composing it appeared to be striated, and to be of even luminosity throughout."

The most northern observatory at which the comet was observed was the Lick, and the orbit rests entirely on the measures made in the southern hemisphere. Mr. Merfield, employing three normal places extending from May 6 to June 6, derived a very elongated ellipse, but he appears to prefer a parabolic motion. The perihelion distance, though small, is much greater than is the same element in the family of southern comets from 1843 to 1882, so that no connection is probable between the 1901 comet and the other brilliant visitors of which so many examples have appeared in the last few years.

The only other comet that has been under observation is that of Encke. The preparation of the ephemeris to assist its recovery was undertaken by Dr. Thonberg, of the Kronstadt Observatory, and the comet was found by Professor Wilson, of Northfield, U.S.A., on August 5, very near the predicted place. The earliest observations showed that the mean anomaly required a correction of $-4'\ 24''$, or that the time of perihelion passage was in error about six hours. The path of the comet at first through *Gemini* and *Cancer* allowed observations to be made in the northern hemisphere, but early in September the comet moved rapidly to the south, and was too near the Sun to be visible. In October the comet was south of the Sun and observations were only possible in the southern hemisphere, and details have not yet been published.

To this scanty record of cometary observation must be added the unwelcome fact that two comets have passed through perihelion without being seen. The first of these, that of

Brorsen, was looked for in vain at Arequipa, where a systematic search was maintained by means of the Bruce photographic telescope. The date of the perihelion passage of Comet 1894 I. (Denning), the other missing comet, is extremely uncertain, but short sweeping ephemerides were prepared by Dr. Neugebauer, apparently without success.

Definitive elements of several comets have appeared during the year, and in this field of heavy work we may recognise the services of Mr. C. T. Merfield, of Sydney, who, besides doing much useful work in the way of supplying orbits and ephemerides of comets while under observation, has calculated definitive elements of Comets 1898 VII. and 1899 I., both of which are hyperbolic. The orbits of several other comets have been placed in a more satisfactory position by the efforts of other computers, and it seems likely that a stimulus will be given to this class of work by the proposal of Mr. Lindemann, of Sidmouth, to give a money prize for the satisfactory determination of the orbits of many comets which have hitherto been neglected. W. E. P.

Progress of Meteoric Astronomy in 1901.

January Meteors.—Moonlight and cloudy weather prevented the *Quadrantids* being successfully observed in 1901.

April Meteors.—The shower of *Lyrids* was well seen on April 21, but on previous nights meteors were rather scarce, though the skies were clear and free from moonlight. On April 21 the hourly rate of apparition of all meteors for a single observer was about 25, of which number one-half were *Lyrids*. They were rather swift, bright meteors with streaks, and the radiant appeared to be about 5° in diameter, with centre at 270°+33°. A moderately bright *Lyrid* was well observed at Slough and Bristol on April 18, and indicated the radiant at 266°+33° on that date, thus affording a new and significant link in the evidence affirming the easterly motion of the radiant of about 1° per diem. At Bristol, during a watch extending over 5 hours on April 20 no certain *Lyrids* were noticed among a total of 29 meteors recorded, but Professor Herschel, at Slough, saw several *Lyrids* on the same night. On April 21, during a watch of 3 hours, he enumerated 18 *Lyrids*, while at Bristol 25 *Lyrids* were registered in $3\frac{1}{4}$ hours. On April 21 Mr. C. L. Brook, at Meltham, near Huddersfield, saw 40 or 50 meteors, including a number of *Lyrids*. On April 12, 17, and 22 Mr. J. C. W. Herschel, at Cambridge, observed 60 meteors, of which 40 were directed from the region of *Lyra*. The radiant appeared to be multiple, and exhibited no traces of motion. Professor A. S. Herschel, from an investigation of many of the paths recorded by different observers, concluded that they gave "two mean centre-points, at 266°+30° to 271°+30°, the latter being chiefly marked on April 21, and then very sharply defined, while the former point

ceased to be traceable after April 20 ; hence if a real motion of the time was thus indicated in the radiant point's position, it seemed to be onwards in R.A. about 5° on the four nights, April 18–21, along a parallel of declination."

July and August Meteors.—Moonlight prevented observation at the close of July and early part of August. At the middle of July the weather was tolerably clear, but meteors were rather scarce. The first *Perseids* were noticed on July 21, when the radiant point of the shower was at 23°+52°. At Bristol the nights of August 10 and 11 were fine, and 172 meteors were observed. August 12, 13, and 14 were cloudy, but an unusually long period of clear weather followed, for the 10 nights from August 15 to 24 offered excellent opportunities for tracing the *Perseid* shower through its later stages, and 220 meteors were observed by Mr. Denning. There were a few *Perseids* visible on every night of the period, and the easterly movement of the radiant was well marked. The maximum of the shower appeared to be attained on the morning of August 13, but the cloudy state of the firmament prevented fair comparisons being made. Mr. Wm. Mitchell, of Maine, U.S.A., saw 42 meteors in the hour between 10 and 11 on August 13, and Mr. R. M. Dole, at Oganquit, U.S.A., counted 79 *Perseids* in 5 hours between 8.30 and 13.30 on August 13, so that the display certainly exhibited unusual strength at a period which we regard as late for the *Perseids*. Miss Bolton, at Leeds, counted 125 *Perseids* on August 10 in $2^h\ 25^m$, while on the night of August 11 119 were noted in slightly less than 2^h, so the numbers were nearly similar on the two nights. On the whole the display was decidedly richer than that witnessed in an ordinary year, and furnished the usual proportion of large meteors, some of which were registered at several stations and their real paths ascertained. A great number of astronomers, at home and abroad, participated in the observations, but it is impossible to refer to their individual results, many of which have already been published in *Astronomische Nachrichten*, *Nature*, *Popular Astronomy*, *Journal of the B.A.A.*, *English Mechanic*, and other serials.

October Meteors.—This shower was fairly well seen at several stations, but it was not of special character. As observed at Bristol on the night of October 20, the principal radiant was at 99°+13°, as on 1900 October 23. Formerly the chief centre was at 92°+15°, and it will be important to watch the *Orionids* thoroughly during the ensuing few years to ascertain whether the stronger shower emanates from *υ Orionis* or *ξ Geminorum*. Mr. R. M. Dole, at Jamaica Plain, Mass., kept a watch on October 19 between 13^h * and $16^h\ 15^m$,* and observed 89 meteors : 55 of these were from the *Orionid* radiant, 11 from *Gemini*, 8 from *Taurus*, 3 from *Leo*, 5 from *Perseus*, and 4 from *Aries*. The

* In all cases local times are given. This description and some others relating to the *Leonids* are condensed from *Popular Astronomy*.

maximum was attained at $13^h\ 40^m$–$13^h\ 50^m$. There were some curious meteors; one from *Pegasus* lit up earth and sky like the new Moon, and curved as it died out so that it made a semicircle. Two of the meteors from *Gemini* started as lines and broadened as they shot. One, which was as bright as *Venus*, made a triangle; another ended in a burst about 1° in diameter. The *Orionids* came in shoals with a maximum every 20 minutes.

November Meteors.—The *Leonids* were not expected to appear in unusual numbers in 1901, but the shower was very generally looked for, and the weather being favourable just at the important time the results obtained were satisfactory if they were not sensational. The display was well marked, but it is certain that the maximum occurred after sunrise in England on November 15, so that the results obtained in this country are not nearly on a parallel with those coming from America. The following are a few extracts from the descriptions of the shower :—

Observer.	Date.	Time of Watch.	Duration.	Leonids.	Other Meteors.
		h m h m	h m		
A. S. Herschel, Slough	Nov. 14	11 to 15¼	4¼ hrs.	6	...
	15	12½ „ 15¾	3¼ „	12	...
J. H. Bridger, Farnborough	Nov. 14	14 37 „ 16 22	1 45	18	
	15	16 55 „ 18 0	1 5	6	2
P. M. Ryves, near Exeter	Nov. 14	12 22 „ 15 0	2 10	20	26
	15	13 20 „ 17 0	2 30	51	35
H. Corder, Bridgwater	Nov. 14	... ...	1 30	37	13
C. L. Brook, Meltham	Nov. 13	15 0 to 16 30	1 30	2	8
	14	14 45 „ 18 15	2 55	59	13
	15	14 20 „ 18 15	3 10	28	11
	16	14 35 „ 17 40	2 35	13	18
E. C. Willis, Norwich	Nov. 14	13 0 „ 17 50	4 45	106	94
	15	11 45 „ 17 35	5 0	89	89
	16	12 15 „ 14 15	2 0	7	29

A watch was kept at Greenwich on November 14, 15, and 16, and between 40 and 50 *Leonids* were seen after midnight on each of the two first nights. Mr. P. M. Ryves gives the maximum as occurring on November 15, 16^h to 17^h, when there were 27 *Leonids*. Mr. W. H. Milligan, of Belfast, says that on November 14, between $15^h\ 30^m$ and 18^h, the horary rate of all meteors was 40 to 50, and that the maximum was at about 17^h. Mr. J. R. Heury, of Dublin, watching the sky on November 14, between 13^h and $15^h\ 30^m$, says the meteors of the first and second magnitudes shot steadily from the Sickle at the rate of about 12 per hour.

In America meteors were much more plentiful. At Carlton College, Northfield, Minn., one observer watched the sky on November 14 from $12^h\ 30^m$ to $17^h\ 50^m$, and during this interval of $5^h\ 20^m$ counted 621 meteors. For an hour before $15^h\ 30^m$ 124 were seen; from $15^h\ 30^m$ to $16^h\ 30^m$, 209; and from $16^h\ 30^m$ to $17^h\ 30^m$, 187. Another observer during the latter period counted 100 meteors in 27 minutes, none of which were less in brightness than a star of mag. 2. Mr. Payne estimates that four observers might possibly have counted 1600 meteors (large and small) per hour. Several brilliant fireballs were noted. Mr. Winslow Upton, of the Ladd Observatory, Providence, gives the following numbers :—

	h	m		h	m	Leonids.	Sporadic.
Nov. 14	15	0	to	15	30	34	1
	15	30	„	16	0	58	7
	16	0	„	16	30	61	7
	16	30	„	17	0	66	7
	17	0	„	17	30	60	8

There were about 2 *Leonids* per minute between $15^h\ 30^m$ and $17^h\ 30^m$.

Mr. E. L. Larkin, at Echo Mountain, Virginia, maintained a watch on the night of November 14, with the following results :—

	h	m		h	m	Meteors.
Nov. 14	12	0	to	13	0	32
	13	0	„	13	54	27
	13	54	„	14	43	Clouds
	14	43	„	15	0	19
	15	0	„	16	0	173
	16	0	„	17	0	297
	17	0	„	17	40	109

Thus between $16^h\ 0^m$ and $17^h\ 0^m$ meteors appeared at the rate of 5 per minute. The estimated brightness of about one-third of the total number seen was as under :—

	Meteors.
Twenty times brighter than *Venus*	2
Ten „ „ „	3
Five „ „ „	12
Equal to *Venus*	25
„ *Jupiter* at maximum	40
„ *Sirius*	20
„ *Rigel*	120

The streak of one meteor remained visible for 14 minutes; of another, 6 minutes. The magnitudes summarised above show that a large proportion of the visitors were brilliant, yet Mr. Winslow Upton, whose results, obtained at Ladd Observatory, have already been quoted, says that a few only of the meteors seen by him were brighter than stars of the 1st mag.

Mr. W. C. Brenke, at the Observatory of Illinois, reports that three observers there counted 433 meteors on November 14, $13^h\ 30^m$ to $17^h\ 30^m$. The maximum was between 17^h and $17^h\ 5^m$ when the rate of apparition was 288 per hour.

Mr. R. M. Dole, of Jamaica Plain, Mass., counted the following numbers :—

	h	m		h	m	Leonids.	Others.
Nov. 14	15	0	to	16	0	43	0
	16	0	„	17	0	74	4
	17	0	„	18	0	48	4

The maximum was from $16^h\ 30^m$ to 17^h. Three of the meteors were brighter than *Venus*, 2 equal to *Venus*, and 26 equal to *Jupiter*. Mr. W. P. Russell, in Illinois, on November 14, $17^h\ 36^m$ to $17^h\ 40^m$, observed 13 *Leonids*; so the rate of apparition was about 3 per minute. Mr. J. Salloms, at Dunmore, British America, on November 14, $16^h\ 30^m$ to $17^h\ 30^m$, counted 186 meteors, or 3 per minute. At $16^h\ 10^m$ a brilliant *Leonid* travelled from the Sickle to N.W., and left a streak for 20 minutes. Mr. Salloms remarks that the great majority of the meteors appeared to reach points near the horizon before being extinguished.

The display in America would appear to have been pretty rich, on the mornings of both November 15 and 16. A telegraphic despatch from Phœnix states that a shower of great brilliancy occurred on the morning of November 16. In 30 minutes one observer counted 200 meteors. At Los Angeles the fall of *Leonids* was quite marked before daylight on November 16. In the hour from 4 to 5 A.M. one observer saw 385 meteors.

December Meteors.—The *Geminids* seem to have been less active than usual. On December 10, $9^h\ 50^m$ to $10^h\ 30^m$, Mr. T. H. Astbury, at Wallingford, saw 6 meteors, including 2 *Geminids*. Later on the same night, at Bristol, about 17 meteors were recorded in two hours, but there were only 1 or 2 *Geminids*.

Mr. W. E. Besley, of London, watched the sky on December 10 between $11^h\ 12^m$ and $13^h\ 22^m$ and recorded 21 meteors, of which about 9 were *Geminids* from a radiant at $104° + 29°$.

Mr. P. M. Ryves, observing near Exeter on December 10, between $11^h\ 45^m$ and $14^h\ 15^m$, saw 54 meteors, of which 27 were *Geminids*. He noticed that some very rapid small meteors radiated from *Leo Minor* or *Ursa Major*. The sky was very clear, with the exception of a few small clouds which did not materially interfere with observation.

The following is a list of the real paths of bright meteors observed in England during the past year :—

Date. 1901.	G.M.T. h m	Brightness.	Height at First. Miles.	Height at End. Miles.	Length of Path. Miles.	Velocity per Sec. Miles.	Radiant Point. α ° δ °	Observers.
Jan. 13	10 35	F	61	52	54	8	149 − 12	3
28	9 18	½ = ☽	76	16	61	18	106 + 52	4
Feb. 13	10 41	♀	56	26	36	moderate	72 + 41	2
27	8 52	F	103	57	120	12	165 + 6	3
Mar. 6	7 25	F	84	27	66	slow	51 + 43	8
April 1	9 44	F	69	12	67	slow	129 + 25	7
19	9 28	♀	56	52	40	25	226 − 17	3
Aug. 11	11 2	2 + ♀	95	56	64	rapid	45 + 58	5
15	10 48	♃ − ♀	81	61	37	41	52 + 53	2
Sept. 14	8 45	> ♀	66	26	83	20	345 + 1	20
Nov. 10	6 45	½ = ☽	64	55	73	24	55 + 7	10
13	6 53	½ = ☽	90	52	165	33	87 + 34	3
23	10 27	3 + ♀	70	25	57	slow	65 + 23	3
Dec. 4	5 36	= ☽	91	50	64	21	263 + 36	62
16	5 45	½ = ☽	68	54	51	20	105 + 37	3

The letter "F" in the column headed "Brightness" signifies that the object was a fireball with a brilliancy differently estimated by various observers.

A few of the principal meteoric showers observed during the year were as under :—

Date.	Radiant. α °	δ °	No. of Meteors.	Observer.	Name of Shower.
Apr. 20–21 ...	261	+36	8	W.F.D.	
21	270	+33	25	„	*Lyrids*
July 19–24 ...	290	+24	8	„	
Aug. 10	44	+58	55	„	*Perseids*
„	43	+56	15	H. J. Townshend	„
10–20 ...	335	+73	13	W.F.D.	
10–21 ...	290	+53	10	„	
10–21 ...	350	−14	10	„	
10–22 ...	335	+ 1	15	„	
10–22 ...	310	+61	11	„	
11	45	+58	49	„	*Perseids*
„	46½	+57	14	A. King	„
11–12 ...	50	+58	30	W. H. Milligan	„
12	45	+54	10	H. J. Townshend	„
„	47	+58	13	A. King	„

Date.	Radiant. α	δ	No. of Meteors.	Observer.	Name of Shower.
Nov. 14–15 ...	152°	+23°	12	J. H. Bridger	*Leonids*
„ ...	150	+23	...	E. C. Willis	„
14	149	+23	6	A. S. Herschel	„
15	150	+23	12	„	„
14	150	+22	...	T. H. Astbury	„
„	$150\frac{3}{4}$	$+21\frac{1}{2}$	88	W. Upton	„
15	151	$+21\frac{1}{4}$	21	„	„
14	149	$+22\frac{3}{4}$	7	W. H. Robinson	„
14	151	+23	19	W. C. Brenke	„
14	149	+24	63	„	„

Though the shower of *Leonids* was a moderately rich one the photographic results appear to have been very meagre. Mr. H. C. Wilson secured one *Leonid* trail at Northfield, Minn., and this with two others obtained in 1898 appear to prove that the radiant is not an area, but a point at α 10^h 6^m, $\delta + 22°$ 18′.

From Columbia College Observatory Professor J. K. Rees reports that the plates taken on November 14 show a number of trails, including a remarkable one left by a brilliant *Leonid* which appeared on November 14, 15^h 58^m, and left a streak for 20 seconds.

Professor W. H. Pickering, of Harvard, remarks (*Popular Astronomy*, 1902 January) that the observations of the *Leonids* in 1901 appear to induce the belief that the 33·25-year period must be abandoned, and that the swarm has followed an orbit since 1698 whose period is very nearly thirty-four years.

Remembering that brilliant displays of *Leonids* were seen in 902, 1002, 1202, and 1602, it seems possible that a rich return may be visible in 1902 November, though the Moon will be full at the time. The year 1902 is a notable one in connection with the interesting history of this meteoric system, since it is just 1000 years ago—in 902—when it was first observed and recorded.

Telescopic Showers of Daylight Meteors.—Mr. J. Coles, Liphook, Hants, has published an observation made on the afternoon of September 18. While viewing *Arcturus* in a 7-inch Newtonian reflector he noticed a number of bright objects rapidly crossing the field from W. to E. They appeared at the rate of about twelve per minute, and were assumed to be meteors. But phenomena of this kind are comparatively frequent, and are really produced by terrestrial objects floating high in the air. They consist of buoyant seeds such as thistledown, or of snow showers, or flights of gossamer webs, and are quite different from the telescopic meteors with which comet-seekers and observers of variable stars are familiar. That the objects discerned by Mr. Coles and by many others in previous years were not meteors is certain. Mr. Denning has witnessed about a dozen of these

daytime showers while making solar observations, and noticed that the irregular rate and direction of motion of the objects, combined with their aspect and general behaviour, proved them to be sunlit, comparatively near the Earth's surface, and borne along in wind currents which introduced all the vagaries observed. W. F. D.

Solar Activity, 1901.

There can be little doubt that the past year has seen the minimum of the current solar cycle. As it regards both spots and faculæ, the Sun has been more entirely quiet than in any year since 1878. On 297 days out of the 365 it was entirely free from spots—that is to say, on 81 per cent. as compared with 50 in the previous year. Only two groups of any importance were noted, both of which formed on the farther side of the Sun, and came into view first at the east limb. The first of these appeared by a curious coincidence on the day after the total solar eclipse, a great prominence over the place of the spot having been conspicuous during the eclipse. This group was visible during two apparitions, being seen from May 19 to May 30, and again from June 16 to June 26, though in much diminished extent. A fine regular spot ran its course from November 13 to November 25. The other groups were all insignificant and short-lived. The longest periods of complete quiescence were from March 11 to May 18, 69 days ; and from July 25 to October 6, 74 days. The mean daily spotted area for the year will scarcely exceed, if indeed it does at all, that for 1878, which was twenty-four millionths of the Sun's visible hemisphere, or one-sixtieth of that shown during the last maximum.

The Prominences.—The slight falling off in the mean daily numbers of prominences which was noticed in 1900 appears to have continued and to have become much more marked during 1901.

The results derived from observations carried out on a uniform plan at Kenley for the two years are as follows :—

	1900. Per diem.	1901. Per diem.
North hemisphere	3·17	2·56
South „	3·61	3·06
Total mean number	6·78	5·62

The average size of the prominences also shows a decrease in the ratio of five to four.

The southern hemisphere still continues to be more active than the northern in the proportion, roughly, of six to five ; and the distribution of the prominences in latitude during 1901 shows but little change compared with the previous three or four years. By far the largest number have occurred between the

parallels of $+35°$ and $+55°$ in the northern hemisphere, and between $-45°$ and $-55°$ in the southern hemisphere, these zones of maximum activity occupying nearly the same positions as in 1900. The southern zone has, however, encroached a few degrees upon the barren polar region, and the parallels $+60°$ and $-60°$ now mark symmetrically the limits of prominence activity towards the poles.

Herr Fenyi, at Kalocsa, records seventeen prominences of not less than $100''$ in height observed during the year; and one eruption, on June 1, which attained the height of $431''$ in fifteen minutes.

No large prominences of the eruptive class were seen at Kenley, and only one metallic prominence was recorded; this occurred on January 20 in latitude $-6°$. E. W. M. and J. E.

Total Solar Eclipses.

1898 *January* 22.

Two important papers on the spectroscopic results obtained at this eclipse, by Sir N. Lockyer and Mr. Evershed, have been published during the year. (*Phil. Trans.*, 197A.)

Sir N. Lockyer discusses the spectra of both the corona and the chromosphere, and arrives at the conclusion, confirmatory of his previously expressed opinion, that many very strong chromospheric lines are not represented among the Fraunhofer lines and *vice versâ*, and that the chromosphere is, therefore, not the seat of the Fraunhofer absorption.

Mr. Evershed, on the other hand, reaches the conclusion that practically every strong dark line in the solar spectrum is present as a bright line in the flash spectrum, and, conversely, that almost all the flash spectrum lines (except those of hydrogen and helium) coincide with dark lines in the solar spectrum. He thence concludes that the flash spectrum may be considered to represent the upper, more diffused, portion of a stratum of gas which, by its absorption, gives the Fraunhofer dark-line spectrum.

This fully confirms the views held by Professor Frost based on his discussion of the spectrum observations of the eclipse of 1900 May 28, made by the Yerkes Observatory party.

In his examination into the chemical origins of the flash spectrum lines Mr. Evershed arrives at the result that no element having a higher atomic weight than 92 is certainly present, while almost all the known metals with atomic weights less than 60 can be identified. This is quite in accordance with previously accepted opinions, with one remarkable exception—namely, barium, which metal is known to be present in the Sun and is generally supposed to have been detected in the chromosphere. Sir Norman Lockyer includes it in his list of elements,

of which the strongest arc lines are visible in the chromosphere spectrum and some of its lines have long since been observed thickened over spots. The presence of barium in the chromosphere, among elements of much lower atomic weights, seems quite analogous to the extended diffusion of calcium, and neither phenomenon presents any difficulty if we admit a dissociation theory.

1901 *May* 18.

The observations of this eclipse, which, owing to the long duration of its totality, was looked forward to with unusual interest, proved somewhat disappointing, as the weather conditions were decidedly unfavourable. Three British parties took part, Mr. Newall from the Joint Permanent Eclipse Committee, and Mr. Dyson and Mr. Maunder from the Royal Observatory, and a preliminary account of their results has been published.

Mr. Newall, who was stationed at Sawah Loento, in Sumatra, attempted an extensive series of observations, including photographs of the corona both direct and with a polariscopic camera, spectrum photographs with flint, quartz, and grating spectrographs, and a further attempt to get some indication of the rotation of the corona by measuring its velocity in the line of sight. Light clouds obscured the Sun at the time of totality, and the spectrum photographs were thus prevented from being completely successful, though some interesting plates were secured, which will doubtless prove worthy of detailed study. The amount of cloud was not sufficient to seriously affect the direct photographs of the corona, of which a good series was obtained. The corona proved to be of the typical Sun-spot minimal type, with extensive polar streamers round the south pole and shorter ones round the Sun's north pole. The most striking feature is the great disturbance that was evident in the eastern equatorial region, where there was a series of remarkable arches presenting an appearance of connection with a large prominence.

Mr. Dyson, who was assisted by Mr. J. J. Atkinson, was stationed on a small island off the coast of Sumatra and had with him the Thompson coronagraph, some of the slides of which were provided with an occulting shutter of the type used in former eclipses by Mr. Burckhalter, and flint and quartz spectroscopes as used before in India in 1898 and in Spain in 1900. Here also light cloud somewhat vitiated the observations, though apparently no very extensive damage was done to the direct photographs. The results obtained with the spectroscopes do not appear to exhibit any novel features. The corona spectrum shows no new lines, and the chromospheric spectra are of the same character as observed before.

Mr. and Mrs. Maunder were stationed on the island of Mauritius, and in conjunction with the staff of the Royal Alfred

Observatory undertook an extensive programme, chiefly in the form of coronal photographs, with instruments of varying focal length and aperture. Though there was no actual cloud, the definition is described as having been very poor, and a considerable amount of "boiling" was observed at the Sun's limb previous to totality. A large number of successful photographs were, however, obtained.

If the British observers were unfortunate in the weather, the American parties were still more so, and the large expedition from the U.S. Naval Observatory, including in their number Professor Barnard, found their view of totality entirely obscured by clouds. This is all the more to be regretted seeing that Professor Barnard had made preparations for obtaining coronal photographs with a lens of $61\frac{1}{2}$ feet focal length, using plates 40 inches square. With the long exposure that could have been given and Professor Barnard's well-known photographic skill, it is certain that the resulting pictures would have been of exceptional interest and beauty.

The Naval Observatory party had also detachments at two other places, which were more fortunate than the main body. Professor Eichelberger, Dr. Humphreys, and Mr. Peters were at Fort de Kock, the only station in Sumatra where the weather was perfectly clear, and the last-named observer is known to have secured a good set of photographs with a 40-foot telescope. The Lick Observatory party, under the direction of Professor Perrine, was at Padang with an extensive equipment comprising Professor Schaeberle's 40-foot telescope, spectrum, and polariscopic cameras, and a battery of cameras for detecting the presence of an intra-mercurial planet. The long totality of this eclipse made it a unique opportunity for this search, and in spite of the presence of cloud some interesting evidence, apparently all of a negative nature, was obtained. Professor Perrine reports that the best plate showed 37 stars down to about 8·6 visual magnitude, and another one 28 stars down to magnitude 8·8. The failure to find a new planet will not, however, cause any surprise, as, seeing the close scrutiny to which the surface of the Sun has been subjected for many years, and seeing that it is almost inconceivable that a planet inside *Mercury* should not transit the Sun's disk at comparatively frequent intervals, it seems highly improbable that such a body could have escaped detection.

The spectrum photographs taken by this party show a strong Fraunhofer dark-line spectrum in the outer region of the corona, an appearance often before observed, especially when using instruments of considerable light grasp and small dispersion. Professor Perrine considers that his results indicate that the light of the outer corona is almost entirely reflected sunlight, while that of the inner corona emanates from incandescent matter; and he thence concludes that the extensions and streamers are due to matter ejected radially from the Sun at high velocities, such matter being gaseous and incandescent while near the solar

surface and becoming solid at a certain distance. He thus arrives at a theory of the corona similar to that originally propounded by Schaeberle. In connection with this question it may, however, be remarked that previous observers, basing their opinions upon a discussion as to the position in the spectrum of the point of maximum photographic intensity of the coronal light, have reached the conclusion that only a small portion of the light, even of the outer corona, is due to sunlight reflected from small particles, and are thus at variance with Professor Perrine. Another American party, from Amherst College, under the direction of Professor D. P. Todd, were located in Sumatra with an elaborate battery of instruments, but were unfortunate in their weather and obtained but meagre results.

A French party, under the direction of the Comte de la Baume Pluvinel, was at Padang and made some successful observations. No detailed report of their work has, however, yet been published. The same may be said of the large party of Dutch astronomers, and also of the Russian and Japanese observers.

In conclusion, we may say that this eclipse marks little, if any, advance in our knowledge of solar physics. The spectrum photographs secured are apparently not so good as those got either in 1900 or in 1898, and, while detailed examination may reveal points of interest, it is not probable that this scrutiny will reveal anything of fundamental importance. The apparent inter-relation between a disturbed region of the corona and a prominence is interesting, as any connection between the two phenomena was not previously established with certainty, and may serve to throw some light on the physical constitution of the corona.

E. H. H.

Nova Persei.

A new star was discovered in *Perseus* on February 21, $14^h\ 40^m$ G.M.T., by Dr. Anderson, of Edinburgh. It was then of 2·7 magnitude and shone with a bluish-white light. Its approximate place for 1901·0 was R.A. $3^h\ 24^m\ 25^s$, Dec. $+43°\ 41'$. The news was telegraphed to Kiel and appears to have been circulated to most European observatories, and to that of Harvard College for distribution in America by the early evening of February 22.

The star was seen on February 22 (before news of its discovery by Dr. Anderson had reached them) by Mr. Gregg at Hastings, Mr. Gore at Dublin, Mr. Laursen-Nordvig in Denmark, Messrs. Baliasny, Kvasnikoff, and Sviatsky near St. Petersburg.

Of more interest is the announcement by Dr. Glasenapp that the star was seen on February 21, $9^h\ 50^m$ G.M.T., by Mr. Borisiak, a boy of sixteen, at Kiew, who gave the magnitude as 1·5, and wrote to Dr. Glasenapp before the news could have reached Kiew. At the instance of the editor of the *Astronomische*

Nachrichten enquiry was made as to whether any mistake in date could have been made, and he was satisfied that the only error made was in the magnitude of the star, which was probably over-estimated.

Magnitude.—At discovery by Dr. Anderson the magnitude was $2^{m}\cdot7$. Three observers, Messrs. Grimmler, Plassmann, and Schwab, state they were observing the part of the sky in which the Nova appeared on February 21 from 7^{h} to 10^{h} 30^{m}, and consider that the star would not have escaped their notice had it then exceeded $3^{m}\cdot4$. Against this must be set Mr. Borisiak's observation given above. No trace of the star is shown on Harvard College photographs taken on February 18 and 19, which showed stars down to $10^{m}\cdot4$, and a photograph taken by Mr. Stanley Williams on February 20, 11^{h} G.M.T., only 28 hours previous to Dr. Anderson's discovery, showed stars of 11^{m} to 12^{m}, but did not show the Nova.

From February 23 onwards hundreds of observations have been made of the magnitude of Nova *Persei*, and are to be found in the astronomical periodicals and in the circulars of the Lick and other observatories. The light curve from February 19 to April 30 determined from 527 observations, mostly published in *Astronomische Nachrichten* and *Bulletin de la Soc. Astron. de France*, is given by Mr. Child (*Monthly Notices*, vol. lxi. p. 483). A collection of the observations as well as a diagram of the light curve is given by Mr. Wilson in *Popular Astronomy*, vol. ix.

The most complete discussion of the magnitudes yet published is given by the Rev. J. G. Hagen, S.J., as supplementary notes to the "Atlas Stellarum Variabilium" of the Georgetown College Observatory. The new star, which, on February 20, 11^{h}, was $<11^{m}$, and was $2^{m}\cdot7$ on February 21, 14^{h} 40^{m}, rapidly increased to $0^{m}\cdot1$, which it appears to have reached by February 23, 5^{h} G.M.T., and to have remained at this magnitude for about 24 hours. Its magnitude then diminished, at first rapidly and afterwards more slowly, so that it was $1^{m}\cdot0$ about February 25, 7^{h} G.M.T., $2^{m}\cdot0$ on March 1, $3^{m}\cdot0$ on March 10 or 11, and $4^{m}\cdot0$ on March 18. The further decline to $6^{m}\cdot0$, which was reached early in June, was accompanied by oscillations sometimes reaching to nearly two magnitudes, and of period varying from two to five days. The first pronounced *minimum*, though smaller oscillations may have occurred earlier, was on February 19, when the magnitude was $5^{m}\cdot2$. Other minima were on March 22, 25, 28, &c. These oscillations do not seem to have been maintained to any great extent after the early part of June, though as yet the observations have not been collected and discussed. The diminution of magnitude continued slowly to the end of the year, when the Nova was $7^{m}\cdot0$ or a little brighter.

Colour.—An account of the change of colour of Nova *Persei* from February 22 to April 30 is given by Mr. Osthoff in *Astronomische Nachrichten*, 3751. The colours attributed by different observers till May are given in *Popular Astronomy*. At its dis-

covery Dr. Anderson described the colour as bluish-white. There is some divergence among the observers, but it would seem that on February 23 and 24 it was white, a pale yellow on February 25 and 26, becoming orange by the beginning of March and red by March 3 or 4. From March 19, when the oscillations in magnitude began, the colours were orange at a maximum and red at a minimum. It may be noticed that the photographic image of the star was much stronger than that of a red star of similar visual magnitude, possibly in consequence of the large amount of ultra-violet light as shown in the spectrum. According to a paper of Mr. Robinson's (*Monthly Notices*, vol. lxii. pp. 193–199), the changes in photographic magnitude followed closely those of visual magnitude.

Measures of position; proper motion; parallax, &c.—The Nova appears to have been observed with the meridian instruments of nearly every observatory soon after the announcement of its discovery. Measures of its distance from neighbouring stars were made at the Yerkes and Lick Observatories, and photographs of the field for use in determination of the position, proper motion, and parallax appear to have been generally taken. As yet there has not been time for any complete discussion, but it appears probable from the results of Mr. Bergstrand and others that the star can have but a very small parallax, probably beyond the limits of measurement. It was announced by Mr. Bergstrand that the Nova had a considerable proper motion, but his later photographs do not support this view. In this connection attention may be drawn to Mr. Ceraski's note in *Astronomische Nachrichten*, 3755, that a photograph taken 1899 January 30 showed a 12th-magnitude star whose coordinates relatively to the present position of the Nova are $+0^{s}.31$ in R.A. and $-7''$ in Dec. This star has not been seen since the Nova appeared.

Spectroscopic observations.—The spectrum of the Nova has been observed and discussed in the *Monthly Notices* by the Rev. W. Sidgreaves and by Mr. McClean, in the *Proceedings* of the Royal Society by Sir N. Lockyer, in the *Astrophysical Journal* by Professor Hale and Professor Vogel, in a circular of the Lick Observatory (republished in *Astroph. Journal*) by Professor Campbell and Mr. Wright, in Harvard College Circulars by Professor Pickering, and in the *Astronomische Nachrichten* by Mr. v. Gothard.

The earliest photographs of the spectrum of Nova *Persei* were obtained at Harvard College on February 22. The star had a strong continuous spectrum and was traversed by thirty-three dark lines. The general appearance was that of the *Orion* type of stars. The spectrum was similar on February 23, but on February 24 the spectrum was a strong continuous spectrum traversed by bright lines accompanied on the violet side by very broad absorption bands. The contrast between the bright and dark bands was much stronger on February 25, on which day it

resembled that of Nova *Aurigæ* at the time of its discovery. The bright bands at H and K were crossed by fine dark lines (calcium), and a bright band at D was crossed by fine dark lines at D_1 and D_2 (sodium). These lines were only slightly displaced, and indicated a small velocity of recession. The maxima of the bright bands H_β, H_γ, H_δ were displaced 8 tenth metres to the violet, according to the measures of Professor Campbell and Mr. Wright. The changes in the appearance of the spectrum from February 27 to March 28 are shown in photographs given by Professor Hale in *Astroph. Journal*, p. 238, the most remarkable being the diminution of the bright lines on the red side of H_β. The dark bands accompanying the bright bands had changed by March 13 to numerous fine lines, of which the strongest had the greatest wave length, and was at the edge of the bright lines. The bright hydrogen lines were displaced about 5 tenth metres to the red. The dark hydrogen bands, the dark H and K bands (while they lasted), and the dark sodium band were all displaced to the violet by an amount $\Delta\lambda = -\cdot 0046\lambda$ (Campbell and Wright).

The spectra underwent periodic changes in accordance with the changes in the star's brightness. At a maximum the continuous spectrum was stronger relatively to the bands. These changes are shown in Father Sidgreaves' paper in *Monthly Notices*, lxii. p. 146.

On July 9 it was announced by Professor Pickering that the spectrum of the Nova was that of a nebula and showed the usual nebular lines.

A spectrograph obtained at Lick on July 15 along with a comparison with N.G.C. 7027, and accompanied with an intensity curve, shows corresponding to each line in the nebula a band in the Nova, the bands having generally similar intensity curves. The principal maxima of these bands are at their violet edges, and are displaced from the normal positions of the nebular lines by an amount $\Delta\lambda = -\cdot 00212\lambda$.

Nebulosity round Nova Persei.—On August 21 Messrs. Flammarion and Antoniadi announced that photographs of the Nova taken by them on the 19th and 20th showed a nebulous aureole. The matter was taken up by Dr. Max Wolf, who showed that the aureole was due to the peculiar character of the light of the star, but found what appeared to be a real but very faint trace of nebula about 5′ south of the Nova. As this was near the limit of his instrument he suggested that the region should be photographed by the Crossley reflector. Mr. Ritchey at the Yerkes Observatory obtained on September 20 with a 24-inch mirror and an exposure of $3^h\ 50^m$ a nebulosity round the Nova reaching to a distance of about 6′ and showing remarkable condensations in various parts. Mr. Perrine, of the Lick Observatory, by comparison of this photograph with one he obtained on November 7 and 8, showed that the principal condensations shown on Mr. Ritchey's photograph were in rapid motion,

amounting to no less than 11′ a year. This result was independently obtained by Mr. Ritchey from a photograph taken on November 9. In the *Astrophysical Journal*, vol. xiv., reproductions are given of photographs obtained at Yerkes on September 20 and November 13, which show these remarkable changes in the clearest manner.

The velocities indicated taken in connection with the probable small parallax of the Nova are comparable with the velocity of light. Mr. Max Wolf pointed out in *Astronomische Nachrichten*, 3753, that an assumption of a linear velocity equal to the velocity of light would imply a parallax of 0″·012. He threw out the suggestion that the luminosity was caused by the progress of an electric wave through nebulous matter at rest. Professor Kapteyn in *Astronomische Nachrichten*, 3756, offered as an explanation that the light from the star was reflected to us by the nebulous matter, and that the photographs show the light travelling out from the star.

Suggestions have also been made that an explanation of these high velocities is to be sought in the recent physical discoveries associated with the names of Professor Thompson and Sir W. Crookes. Other astronomers are of opinion that though the velocities are extremely great for ordinary matter, they are not inconceivably so when the extraordinary character of the Nova is contrasted with the everyday phenomena of solar prominences.

Conclusion.—It is too soon to enter into the hypotheses which have been put forward to explain the genesis and the subsequent behaviour of Nova *Persei* and of new stars in general. The questions are still *sub judice*. It may be remarked, however, that facts relating to Nova *Persei* have been collected in great volume and importance. The observations of the spectrum at an early date while the brightness was still increasing, the many observations of the spectrum since this time, and the discovery of the nebula in particular have put astronomers in possession of much fuller and completer data for attacking the interesting and difficult questions incident to the formation of *New Stars*. F. W. D.

Double Stars.

The present summary of references is arranged, as in former years, under the two heads, "Observation" and "Calculation." Abbreviated titles have been used as follows :—

M. N.: Monthly Notices, R. A. S.
A. N.: Astronomische Nachrichten.
A. J.: Astronomical Journal.
A. S. P.: Astronomical Society of the Pacific.
L. O. B.: Lick Observatory Bulletin.
P. A.: Popular Astronomy.

Observation.—Measures of some stars of special interest will be found :—

Sirius ...	R. G. Aitken, *A. S. P.* 79 ; *L. O. B.* 11.
Procyon ...	R. G. Aitken, *A. S. P.* 79 ; *L. O. B.* 11.
δ Equulei...	R. G. Aitken, *A. S. P.* 79 ; *L. O. B.* 11.
	W. Hussey, vol. v. *Lick Publications.*
β 883 ...	R. G. Aitken, *L. O. B.* 11.
	T. Lewis, *M. N.* 1901 May.
	W. Bryant, *M. N.* 1901 May.
	W. Bowyer, *M. N.* 1901 May.
R Pegasi ...	R. G. Aitken, *L. O. B.* 11.
	H. Struve, vol. xii. *Poulkova Publications.*
	T. Lewis, *M. N.* 1901 May.
	W. Bryant, *M. N.* 1901 May.
	W. Bowyer, *M. N.* 1901 May.

New Double Stars—

W. J. Hussey. A. J. 494. Third Catalogue of new doubles. 37 pairs under 1″·0.

W. J. Hussey. P. A. 1901 Feb., finds the principal star of β 168 a close double.

W. J. Hussey. A. S. P. 80, finds principal star of 66 *Tauri* a close double (0″·2) ; also of Σ 2339, which is 0″·2.

W. J. Hussey. L. O. B. 12. Fourth Catalogue of 100 new doubles. 67 pairs under 1″·0.

R. G. Aitken. L. O. B. No. 3. Third Catalogue of new double stars. 43 pairs under 1″·0. The mean results are also in *A. N.* 3731.

R. G. Aitken. A. S. P. 81, finds the principal star of β 986 a close double.

Rev. T. E. Espin. A. N. 3717, 39 new doubles, 8 under 5″.

Measures of Known Pairs—

Rev. T. E. Espin. A. N. 3717. 84 wide neglected doubles.

L. Brenner. A. N. 3753. Measures of γ *Andromedæ.*

J. Tebbutt. M. N. 1901 May. Measures of 28 pairs in 1899 and 1900.

J. Gledhill. M. N. 1901 June. 34 binary stars (9-inch refractor).

Royal Observatory, Greenwich. M. N. 1901 May. "Results of micrometric measures of double stars with the 28-inch refractor in 1900." 368 stars ; 218 under 1″·0.

W. A. Cogshall. A. J. 505–6. Measures with the Lowell 24-inch of stars discovered by Dr. See.

E. Doolittle. A. J. 486. Motion in the system *Krueger* 60.

R. G. Aitken. L. O. B. 11. Measures of 194 double stars in 1900–1.

W. J. Hussey. A. S. P. 80. Note on *Capella.*

Cape Double Star Results. M. N. vol. lxi. No. 9. 500 southern stars, 52 of which are new pairs.

E. Doolittle. Measures of 900 double and multiple stars made at the Flower Observatory.

Hermann Struve. Measures of 900 double stars made with the 30-inch Poulkova refractor from 1885 to 1895. Vol. xii. series ii. *Poulkova Publications.* 76 stars under 0″·5; 127 between 0″·5 and 1″·0; 164 between 1″·0 and 2″·0; the remainder being over 2″.

Calculation.—The following papers dealing with calculation and general literature have appeared in the course of the year :—

ζ Sagittarii	R. G. Aitken, *P. A.* 1901 Feb.; orbit, period 21·2 years.
ξ Boötis ...	G. C. Comstock, *A. J.* 503; orbit, period 172 years.
η Cassiopeiæ	G. C. Comstock, *A. J.* 512; orbit, period 500 years.
Σ 3062 ...	J. Larsen, *A J.* 505–6; orbit, period 114·2 years.
Σ 1639 ...	T. Lewis, *M. N.* 1902 Jan.; orbit, period 180 years.
β 107 ...	S. W. Burnham, *P. A.* 1900 Dec.; Note on.
β Cassiopeiæ	S. W. Burnham, *P. A.* 1900 Dec.; Note on.
β 182 ...	S. W. Burnham, *P. A.* 1900 Dec.; Proper motion of.
Σ 325 ...	W. Hussey, *P. A.* 1901 Feb.; principal star has a proper motion of 0″·16 in 302°.

Special mention must be made of vol. v. of the *Lick Observatory Publications.* In this volume Professor W. Hussey has collected all the Otto Struve pairs (OΣ) in order, and gives the whole history of each pair, its catalogue place, the micrometric measures (with references to original sources), and, where possible, a discussion of these measures, accompanied with diagrams, which are also valuable as enabling observers to tell at a glance what stars require observation. Beyond the actual collection and arrangement of measures of other observers, Professor Hussey has examined in all 612 stars, made measures of 547 of them, and found 65 to be single. The work is modelled on the Yerkes volume, and is, like it, a standard of reference.

T. L.

Photometry and Variable Stars.

The past year has been characterised by great activity in the department of variable stars, and the following new variables have been announced. The list does not pretend to be exhaustive.

Z

	Identification.	R.A. h m	Dec. ° ′	Epoch.	Discoverer.	Reference, &c.
69	1901 Andromedæ	0 43·5	+33 35	1855	Anderson	*A. N.* 3698
74	1901 Persei	3 2·7	+44 29	1900	Guthnick	„ 3720
68	1901	3 17·8	+43 39	1855	Williams	„ 3698
75	1901 „	3 24·8	+44 19	1890	Deichmüller	„ 3720
71	1901 Aurigæ	5 18·3	+42 18	1855	Williams	„ 3708 short period
		10 16·7	−41 44	1875	Roberts	*A. J.* 508 Algol type
77	1901 Herculis	16 25·8	+ 7 9	1855	Anderson	*A. N.* 3738
76	1901 Ophiuchi	17 49·6	+11 11	1855	„	„ 3731
		18 32·8	+43 50	1855	Williams	„ 3670
73	1901 Scuti	18 46·3	−12 47	1855	Ceraski	„ 3718 Algol type
		18 54·3	+34 45	1855	Williams	*A. N.* 3671
72	1901 Lyræ	19 7·6	+33 10	1855	Ceraski	„ 3718
2	1901 Cygni	19 12·2	+49 55	1855	Anderson	„ 3692
93	1901	19 14·4	+19 25	1900	Schwab	„ 3748 Algol type
1	1901 „	19 28·0	+28 0	1855	Williams	*A. N.* 3687
		19 43·3	+48 49	1900	Hisgen	„ 3669
78	1901 „	20 18·0	+42 46	1855	Williams	„ 3740 Algol type
96	1901 „	20 49·0	+29 52	1855	„	*A. N.* 3751–2
20	1900 „	20 59·8	+28 50	1855	„	„ 3675
94	1901 „	21 17·7	+41 52	1875	Deichmüller	„ 3751
95	1901 Pegasi	21 37·9	+24 21	1855	Anderson	„ & 3752
		22 4·6	+13 38	1855	„	„ 3670

Harvard College Observatory Circular, No. 54, gives a list of sixty-four new variable stars, the greater part being discovered from the presence of bright hydrogen lines in their photographed spectra. They are mostly situated in low southern declination. Thus the work of finding new variables in the southern hemisphere more than balances that in the northern.

An epoch in the progress of stellar photometry is undoubtedly marked by the publication of *A Photometric Durchmusterung*, which forms vol. xlv. of the *Annals* of Harvard College Observatory. This work contains the photometric measurements of all stars of the mag. 7·5 and brighter, north of declination −40°. There are also included the magnitudes of certain stars fainter than the limit mentioned, which are likely to be used as comparison stars for variables, and of other faint stars. The total number of stars included in this catalogue does not appear to be named therein, but an idea of the number may be surmised

from the fact that the catalogue proper consists of some 300 closely printed pages, each page having a double column of stars : on the average there may be perhaps eighty stars to a page. The following particulars are given for each star : (1) D.M. number. (2) Position in R.A. and Dec. for 1900. (3) D.M. mag. (4) Photometric mag. (5) Julian dates of observations. (6) Residuals found by subtracting the mean mag. from the individual measures. This catalogue, the result of years of labour on the part of Professor Pickering, must doubtless be of the very greatest value to all workers in variable stars, as well as for statistical purposes in connection with the distribution of stars, generally, in the heavens.

In the annual report of the director of the Harvard College Observatory it is stated that over 16,000 photometric comparisons have been made with the east equatorial ; several thousands of observations with the west equatorial. With the 12-inch meridian photometer, 54,448 settings have been made by the director. With the meridian photometer 33,316 settings have been made, bringing the total number with this instrument up to the huge number of 1,033,180. As regards photography, we learn that the 8-inch Draper telescope covers the whole northern sky to S. Dec. 12°·5, from two to four times a year. The Cooke lens covers all the sky visible at Harvard two or more times a month, while the transit photometer furnishes on every clear night a record of all stars crossing the meridian, and visible to the naked eye. Over 28,000 photographs have been taken in all at Arequipa. A further discussion of photographs of variable stars in clusters is in hand.

Dr. S. C. Chandler has announced that owing to pressure of work he is unable to undertake the preparation of a fourth catalogue of variable stars as he had hoped. The Council of the *Astronomische Gesellschaft*, however, are taking up the work, and ask for any unpublished observations which may be of use in determining light-periods to be sent in to them.

Dr. A. W. Roberts, of Lovedale, Cape Colony, has produced (*A. J.* 491–492) an excellent catalogue of southern variable stars, on the lines of Chandler's third catalogue. This is largely the result of his own long-continued observations ; and the high character of his work accordingly lends great weight to this catalogue, which includes ninety-four variables, all south of − 30° Dec.

The variable star section of the British Astronomical Association has for the past two years been engaged in the systematic observation of a selected number of variable stars, of well-established or popular character. This working list contains forty-six stars embracing the different types of variation. Since 1900 January some 5000 observations have been made on the method of Argelander, and the results published from time to time in the *Journal B. A. A.* Co-operation in the work is the guiding principle, and with this in view the observations are concentrated on the above-mentioned limited number of stars.

Maps of the vicinity of each variable, together with lists of comparison stars and their brightness, have been issued to each observer. In addition, a uniform method of making and recording the observations is adopted. The number of workers is but few; but the results already achieved show how much may be done by co-operation in observation of variable stars. Professor Pickering very liberally furnishes photographs of the vicinity of certain variables as seen in the maps of the D.M. to any regular observers who wish for them. E. E. M.

Stellar Spectroscopy in 1901.

Spectrum of nebulæ.—Professor Campbell in his researches on the spectrum of Nova *Persei* has secured photographs of the planetary nebula *N.G.C.* 7027, and in the *Bulletin* No. 8 of the Lick Observatory he gives a reproduction which shows the narrow bright lines with admirable clearness. (Reprint in *Astroph. Jour.* xiv. 269, fig. 12.)

New stars and stars with peculiar spectra.—The phenomena presented by Nova *Persei* are dealt with in a separate note, p. 307.

Professor E. C. Pickering refers (*Ast. Nach.* **155**, 124) to the observations obtained of Nova *Aquilæ*, which was discovered in 1899 by Mrs. Fleming on the Draper Memorial photographs. In the later photographs the only lines seen in the spectrum are Hγ and 5007.

Professor Pickering gives the results of further investigations of the second series of hydrogen lines detected in the spectrum of ζ *Puppis* (*Ast. Nach.* **155**, 231; *Astroph. Jour.* xiii. 230).

Sir David Gill contributes a note on the spectrum of η *Argûs* (*Proc. R. S.* lxviii. 456; and *Monthly Notices*, lxi. App. [66].) It appears that the spectrum closely resembles that of Nova *Aurigæ*.

Classification of stellar spectra.—A discussion of the spectra of bright southern stars, which have been photographed at Arequipa with the 13-inch Boyden telescope as part of the Henry Draper Memorial, has been published in the past year. The work has been done by Miss Cannon under the direction of Professor E. C. Pickering; and the memoir forms Part II. of volume 28 of the *Annals of Harvard College Observatory*, Part I. being Miss Maury's discussion of the bright northern stars. The whole volume therefore "furnishes the principal facts regarding the spectra of all the brighter stars from the North to the South Pole;" Part I. dealing with 681 stars north of declination −30°, Part II. with 1122, chiefly in the southern hemisphere. The stars dealt with in Part II. are classified arbitrarily, and divided into thirty-one classes, which are designated according to the notation of the Draper Catalogue, modified so that intermediate classes can be indicated.

Velocity in the line of sight.—The most notable event in this branch of the subject is the publication of Professor Campbell's "Preliminary determination of the Motion of the Solar System" (*Astroph. Jour.* xiii. 80), based on the radial velocities measured at the Lick Observatory. The 280 stars available for this research were divided into 80 groups by combining neighbouring stars into one group. The following elements of the solar motion were obtained :—

$$\text{Velocity} = -19{\cdot}89 \text{ km/sec} \pm 1{\cdot}52$$
$$\alpha_0 = 277^\circ\ 30' \qquad \pm 4^\circ{\cdot}8$$
$$\delta_0 = +19^\circ\ 58' \qquad \pm 5^\circ{\cdot}9$$

Stars with large radial velocity.—Professor Campbell gives (*Astroph. Journ.* xiii. 98) the following examples :—

ε Andromedæ	−83·7 km/sec.	*θ Canis Majoris*	+96 km/sec.
μ Cassiopeiæ	−97·4	1 *Pegasi*	−76
δ Leporis	+95	*μ Sagittarii*	−76
Groombridge 1830	−95		

Variable radial velocity.—Six stars with variable radial velocity have to be added to the list given in last year's report.

	α h m	δ ° ′	Discovered.		Reference.	
ξ Piscium	1 48	+ 2 42	Lick Observatory.		Lick Obs. *Bull.* No. 4 (*Astroph. Journ.* xiv. 138).	
ξ_1 Ceti	2 8	+ 8 23	„	„	„	„
π Persei*	2 47	+52 22	„	„	„	„
ε Hydræ	8 42	+ 6 48	„	„	„	„
o_1 31 Cygni*	20 10	+46 26	„	„	„	„
π Cephei	23 5	+74 51	„	„	„	„

* This star occurs in list of stars with composite spectra (*Ann. Harv. Coll. Obs.* xxviii. 93).

Orbits of spectroscopic binaries.—Orbits for the following stars have been published :—

α Ursæ Minoris	Hartmann	Berlin Akad. Sitzb. 1901, 444 *Astroph. Jour.* xiv. 52
ζ Geminorum	Campbell	„ „ xiii. 90
ζ Ursæ Majoris (Mizar)	Vogel	Berlin Akad. Sitzb 1901, 534 *Astroph. Jour.* xiii. 324 2nd Paper. Arch. Néerl., Harlem 1901, 661
α Aurigæ	Campbell & Reese	Bull. Lick Obs. No. 6 *Astroph Jour.* xiv. 261
η Pegasi	Campbell & Crawford	Bull. Lick Obs. No. 5 *Astroph. Jour.* xiv. 202

New Instruments.—Professor Frost describes (*Astroph. Jour.* xv. 1) the new Bruce spectrograph of the Yerkes Observatory, and also the methods adopted in measuring and reducing the photographs. As examples of the results obtained, details are given of a photograph of *α Arietis*, for which a velocity of −13·66 km./sec. is deduced, in good agreement with the results obtained by Campbell −14·1 Vogel and Scheiner 14·7 and Lord −14·0. Three photographs of *ε Leonis* give velocities +4·4, +3·5, +4·0 km./sec. ; thus the variability previously suspected is not corroborated, and the new results are in complete agreement with Wright's measures at the Lick Observatory.

Dr. J. Hartmann describes (*Zeitsch. f. Inst. Kunde*, xxi. 1901, p. 313) a careful set of observations of the effects of changes of temperature in the Potsdam spectrographs, and gives a description of the method of controlling the temperature of the large spectrograph to be used for the determination of the radial velocity of stars. An automatic arrangement has been adopted for switching the requisite electric currents through wires stretched inside the cover which enclosed the whole spectrograph.

Reduction of observations.—Dr. J. Hartmann gives a full account of the procedure adopted at Potsdam in measuring and reducing the photographed spectra of stars (*Ast. Nach.* **155**, 8).

H. F. N.

Revision of Taylor's Madras Catalogue for 1835·0.

The revision of an old catalogue must always be a source of anxiety to the revisor, for the policy of revision and the amount of revision required are inseparably mixed up, and are practically only to be justified by the final results.

Dr. Downing some years ago undertook the superintendence of the work involved in revising the star places of the Madras Catalogue. A succession of grants from the Royal Society has paid for the expense of the calculation, and the cost of publication has been borne partly by the India Office and partly by the Royal Society. It may be a truism to say that the two cardinal principles which underlie the value of such a work are, first and foremost, that the observations themselves and the data on which they depend are of such a character that when reduced on modern principles with modern data they compare favourably with modern results ; and, secondly, that the revision shall be sufficiently thorough to produce the best results from the originals. With reference to the first point, a study of the Madras volumes of observations can only tend to impress the reader with a very high opinion of Mr. Taylor and the enormous difficulties he had to contend with. Occasionally the Observatory was blown down about his ears ; everlastingly the marks on which his azimuth error depended caused him constant trouble.

In *Madras Observations*, vol. ii., p. 42, he says: "On a late occasion I paid a visit to the south mark, which is at the end of a very substantially built brick dwelling-house situated about $1\frac{1}{2}$ mile from the Observatory; here I found a crack in the wall about two inches wide, which is just sufficient to account for the alteration above found; the north mark is a square (brick and chunam) pyramid of weather-beaten and rough exterior, thereby offering no means of detecting a small alteration of the foundation; but from the nature of the soil (a bed of loose sand) it is easy to believe that a considerable fall of rain (such as happened about this date) might have produced the alteration in question."

With reference to the second point, Dr. Downing remarks in his introduction: "The revision of a catalogue of 11,000 stars is a work of such magnitude that it was necessary to exercise the utmost vigilance in order to keep the expenses within reasonable limits, otherwise there would have been a danger of the work being left in an unfinished state. Hence the necessity of utilising, as far as possible, the existing material."

Whether the first or the second principle has been violated there is not sufficient evidence to give an opinion, but that the revised Catalogue is affected by considerable systematic errors is shown by the following comparison with Newcomb's Fundamental Catalogue given by Dr. Downing at the end of the Introduction:—

Limits of Dec.	$\Delta\alpha$.	$\Delta\delta$.	No. of Stars.
	s	"	
+75° to +65°	+·172	+0·44	62
65 „ 55	+·069	+0·69	63
55 „ 45	+·004	+0·91	62
45 „ 35	+·025	+0·78	100
35 „ 25	−·011	+0·51	101
25 „ 15	−·037	00	110
15 „ + 5	−·064	−0·05	117
+ 5 „ − 5	−·064	−0·14	109
− 5 „ 15	−·066	−0·07	91
15 „ 25	−·106	+0·34	86
25 „ 35	−·122	+0·42	52
35 „ 45	−·107	+1·07	54
45 „ 55	−·099	+2·22	40
55 „ 65	−·177	+1·88	41
−65 „ −75	−·199	+1·31	17

A considerable amount of the systematic error can of course be eliminated by application of corrections derived from the above table; and the re-reduction has both lessened the accidental error and eliminated the numerical errors of the original catalogues. W. G. T.

Latitude Variation.

Dr. Chandler has again taken up this subject. In *Astronomical Journal*, No. 489, he discusses all the material available with reference to changes in the annual elliptical component of the polar motions, and comes to the conclusion that the line of apsides is revolving from east to west, or in a direction contrary to that of the pole in its orbit, in a long period of some seventy-five years, or at a rate of about 5° per annum, and the length of the annual period oscillates about its mean value with a cycle of about sixty years.

In *A. J.*, Nos. 490 and 494, he again attacks the theory of polar motion, and finally concludes that it is the resultant of three separate terms, an annual term and two others, whose periods are respectively 428·5 and 436·0 days, motions circular and radii 0″·140 and 0″·090. The superpositions of these two periods is embraced in a cycle of something like seventy years. For five-sixths of the cycle the changes of period vary between 428·5 and 431·4 days, then suddenly shorten to minimum 415 days, and then rapidly lengthen. Similarly, the variations of the radius of motion are singularly asymmetrical. Dr. Chandler bases these assumptions on the discussion of thirty-seven series of observations extending from 1726 to 1900, the results of which are given in convenient tables. He also gives a diagram showing at a glance the comparison between theory and observation, and challenging observation to prove him wrong in a very few years, for the radius of motion is rapidly approaching its minimum value, 0″·05, and the period its minimum length of 415 days.

In *A. J.*, No. 511, and R.A.S. *Monthly Notices*, lxii. p. 122, he gives the results of his discussion of the observations made with the Greenwich reflex zenith tube, and remarks that the instrument "has unwittingly accomplished an even higher service to astronomy than that for which it was intended, and that in place of a fallacious aberration constant and an impossible stellar parallax it in reality contains a body of evidence of the highest value in relation to the constants of the latitude variation during the period which the observations cover. The old discussions are practically attempts to find four unknowns from two equations."

In *A. J.*, No. 513, he gives the determination of the constants of the polar motion from the observations by Molyneux at Kew with his zenith tube, and by Bradley at Wanstead with his zenith sector. He shows how he picked up a mistake of 1″·00 in the line of collimation, and at the same time quotes Bradley to show that the differences in the observations which were troubling him in 1728 were in reality largely due to what we now know as latitude variation, "the vibrations of which anomalies were palpable under his hand, so near did

Bradley come to the discovery of polar motion." And this with only a 2·8-inch object-glass and a few yards of iron tube and wire. W. G. T.

Geodesy.

The *Comptes Rendus* of the thirteenth Conference of the International Geodetic Association, which was held at Paris in 1900, published during the past year, contains a report by Major Burrard of the work of the Indian Trigonometrical Survey. The scheme of this work may be sketched by saying that main lines of triangulation cross the country, east to west, from Calcutta to Karachi, from Vizagapatam to Bombay, and another, north and south, passes through Dehra Dun, Agra, and Kalianpur, so that the country is divided into four quadrilaterals and the South Trigon, each of which is surveyed in detail by minor lines of triangulation. This main survey was finished some years ago, and the work has been extended westward into Persia and eastward into Burmah. Major Burrard refers in his report to this last-mentioned section. The survey of the Burmese peninsula consists at present mainly of a loop of triangulation which was along the western coast to Sandoway, then, turning south-eastward and then northward, passes almost along the meridian 96° east of Greenwich, and the circuit is completed by an east to west chain of triangles through Manipur. This loop is connected to the Indian Survey by two short chains of triangles, and it had been feared that the earthquake in Siam in 1897 must have had results to the serious detriment of this geodetic work. In the report on Indian geodesy made at the previous Conference of the Association in 1898 a fear was expressed that this earthquake might have severed the Indian and Burmese systems of triangulation, but that this could only be proved by the closing of the circuit when the line of triangles through Manipur was completed. Major Burrard reported in 1900 that this line was then finished, and that the re-observation of certain angles showed that no evil effects had been sustained. The closing errors of the great Burmese circuit are worth noting, as they show the degree of accuracy attained by the Indian Survey. The triangulation carried from the junction with the main Survey, southward and round the loop above described, ends in the side of a triangle at Manipur whose length, computed from the chain, is 79,530·40 feet. Its length, computed from the remainder of the loop west of Manipur, is 79,531·22 feet, the discrepancy being only 0·82 foot. The discrepancy in the azimuth of this closing side is 2″·256, and the geodetic position of the closing station as derived from the western chain is 60 feet different from that shown by the eastern observations. In his report to the Conference Major Burrard gave an analysis of the astronomical observations made at stations round Kalianpur to determine the

effect of local attraction, which have since been published in another form,* and have lately formed the subject of a paper presented by him to the Society. The result of these goes to show that the astronomical position of Kalianpur—that place having been chosen by Colonel Everest as the origin of the Survey because the surface of the ground around it gave no sign of deflection—derived from the latitudes and longitudes of the Survey cannot be regarded as absolute.

Sir David Gill's report on the Survey of Rhodesia, some details of which have already been mentioned in the *Monthly Notices*, led to a discussion at the Conference on the merits of the Jäderin base-measuring apparatus, Sir David having mentioned that the brass and steel wires which are the main feature of this apparatus are liable to molecular changes of length.

Attention must be called in this note to the determination of a short arc of longitude, Potsdam-Bucharest, made by Professors Albrecht and Borrass, of the Prussian Geodetic Institute, in which the Repsold registering micrometer, fitted to meridian instruments of the *coudé* type, was used for recording transits. The plan of this micrometer is that the observer causes a movable wire to remain in contact with the star-image and the time of transit is recorded automatically. Judging from the accordance of results shown in this determination, the apparatus must certainly be considered a success. It was expected that the method would diminish the amount of the personal equation, and the difference of this quantity between these observers, which had previously been greater than $0^s{\cdot}10$, became $0^s{\cdot}017$, and at the same time the mean error of the result of one night's determination of a difference of longitude fell from $0^s{\cdot}05$ to $0^s{\cdot}02$.

It may be well to record, though the work was begun earlier than 1901, that the officers of the French Service Géographique de l'Armée are repeating the historic operation of the year 1735 and are determining the length of a degree of the meridian at the Equator. This work is being done in Peru, and M. Gonnessiat, of the Lyons Observatory, has been put in charge of the Quito Observatory for purposes connected with this. At the same time a party of Russian geodesists are making the corresponding measure of a degree of the meridian in Spitzbergen, as Maupertuis did in 1736.

Regret may be expressed here for the death of Dr. Adolph Hirsch, Director of the Neufchatel Observatory, which took place in April last. Dr. Hirsch resigned the secretaryship of the International Geodetic Association, which he had held since 1886, in the year 1900. He had taken a leading part in European geodesy for many years. H. P. H.

* Professional Papers of the Survey of India, Department No. 5.

Papers read before the Society from March 1901 to January 1902.

1901.

Mar. 8. Observations of the partial eclipse of the Sun, 1900 November 22, made at Perth Observatory, Western Australia. Communicated by W. E. Cooke.

On the observation of position angles of polar double stars. R. T. A. Innes.

On the Oxford photographic determinations of stellar parallax : reply to the criticisms of Sir David Gill. H. H. Turner.

Occultations of *Jupiter* and his satellites, 1900 September 29, observed at Windsor, New South Wales. John Tebbutt.

Cape double star results, 1900. Communicated by Sir David Gill.

Observations of the *Leonids*, 1900 November 15–16, made at the Royal Alfred Observatory, Mauritius. Communicated by T. F. Claxton.

Description of a floating photographic zenith telescope and some preliminary results obtained with it. Bryan Cookson.

Note on Mr. Bryan Cookson's paper, "On the accuracy of eye observations of meteors, and the determination of their radiant points." H. C. Plummer.

The variable star *R Centauri*. Alex. W. Roberts.

On the new star in *Perseus*. A. Stanley Williams.

Further corrections to the Armagh Catalogue ; with special reference to the "Anonymous" stars. J. L. E. Dreyer.

Notes on the spectrum of Nova *Persei* observed at the Stonyhurst College Observatory. Rev. W. Sidgreaves.

Positions of Nova *Persei* and 159 stars within 25′ distance from it ; from a photograph taken at the University Observatory, Oxford. F. A. Bellamy.

Note accompanying photographs of the spectrum of Nova *Persei*. Frank McClean.

Observations of the new star in *Perseus* made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

1901.

Apr. 12. A first note on the Nova in *Perseus*. K. D. Naegamvala.

Note on some engraved charts of Pogson's proposed Atlas of Variable Stars. Rev. J. G. Hagen.

Meteoric showers from the region of α—β *Persei* and η *Aurigæ*. W. F. Denning.

Anomalous occultations of stars by the Moon. R. T. A. Innes.

A method of mechanically compensating the rotation of the field of a siderostat. H. C. Plummer.

Variations of *R Horologii* during 1900. Alex. W. Roberts.

Note on meridian observations of Nova *Persei*. A. Graham.

Further observations of the new star in *Perseus*. A. Stanley Williams.

The spectrum of Nova *Persei*, Note 2. Rev. W. Sidgreaves.

The spectrum of Nova *Persei*, Note 3; Nova *Persei* as a variable star with a variable spectrum. Rev. W. Sidgreaves.

Observations of Nova *Persei*. M. C. Sharp.

Further measures of double stars made at the Temple Observatory, Rugby, during the years 1895 to 1900. G. M. Seabroke, H. P. Highton, and E. C. Atkinson.

Observations of the new star in *Perseus* made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Formulæ and tables for correcting coordinates of stars on different photographs, especially different plates of the Astrographic Chart. H. H. Turner.

Further investigation of the "Two Method" personal equation. W. W. Bryant.

May 10. Second note on photographs of the spectrum of Nova *Persei*; correspondence with the spectrum of η *Argûs*. Frank McClean.

Results of double-star measures with the 8-inch equatorial at Windsor, New South Wales, in the years 1899 and 1900. John Tebbutt.

The visual spectrum of Nova *Persei*. Rev. A. L. Cortie.

The spectrum of Nova *Persei*, Note 4. Rev. W. Sidgreaves.

The green flash at sunset. J. Franklin-Adams.

Further observations of the new star in *Perseus* (3). A. Stanley Williams.

Further observations of Nova *Persei*. M. C. Sharp.

The Cambridge machine for measuring celestial photographs. A. R. Hinks.

1901.

May 10. Further observations of the new star in *Perseus*, made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Results of micrometer measures of double stars made with the 28-inch refractor of the Royal Observatory, Greenwich, in the year 1900. Communicated by the Astronomer Royal.

Additional note on the position of Nova *Persei*, and a comparison of photographic magnitudes of neighbouring stars with those of Fr. Hagen's Chart and Catalogue. F. A. Bellamy.

Note on the geometry of the siderostat. H. C. Plummer.

June 14. Observations of *Mars* made at Mr. Edward Crossley's Observatory, Bermerside, Halifax, during the opposition of 1900–1901. Joseph Gledhill.

On a modified form of revolving occulter for adapting the exposure of the Sun's corona to its actinic intensity at all distances from the Moon's limb. D. P. Todd.

The Oxford determinations of stellar parallax. Reply to Professor Turner. Sir David Gill.

Light curve of Nova *Persei*, 1901. Laurence Child.

Sun-spots and magnetic disturbance. William Ellis.

Observations of Nova *Persei* made at Birr Castle Observatory, Parsonstown. The Earl of Rosse.

Secular variation in the period of *R Carinæ*. Alex. W. Roberts.

The great Comet of 1901 as observed at the Royal Observatory, Cape of Good Hope. Sir David Gill.

The Oxford photographic determinations of stellar parallax. Further reply to Sir David Gill. H. H. Turner.

Measures of double stars made at Mr. Edward Crossley's Observatory, Bermerside, Halifax. Joseph Gledhill.

Corrections to reduce the revised Madras Catalogue of stars for 1835·0 to the Fundamental Catalogue of Auwers. A. M. W. Downing.

The *Lyrids*, 1901 April, observed at Cambridge. J. C. W. Herschel.

Further observations of the new star in *Perseus* (4). A. Stanley Williams.

Observations of the Sun during 1901 May 17, 18 and 20, at Mells, near Frome. Maures Horner.

Estimations of magnitude of Nova *Aurigæ* in 1899–1900, with the mean results for the years 1892–1900, from observations at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Further observations of the new star in *Perseus* made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

1901.
Nov. 8. Solar eclipse, 1901 May 18 (observations of the partial phase at Perth Observatory, Western Australia). W. E. Cooke.

The normal equations that arise in the usual schemes of observation for division errors, and their solutions. P. H. Cowell.

Errata in the revised Madras Catalogue of stars for 1835·0. A. M. W. Downing.

Mean areas and heliographic latitudes of Sun-spots in the year 1900, deduced from photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn (India) and in Mauritius. Communicated by the Astronomer Royal.

A new form of reflecting telescope. Charles Anthony.

The green flash at sunset. W. H. Pickering.

Observations of Comet 1901 I. made at Perth Observatory, Western Australia. Communicated by W. E. Cooke.

Note in reply to Mr. Plummer's paper (*Monthly Notices*, vol. lxi. pp. 368–375). Bryan Cookson.

Recent observations of the position of Nova *Aurigæ* with the 40-inch telescope of the Yerkes Observatory. E. E. Barnard.

On the accuracy of photographic measures; being a discussion of a recent paper by M. Loewy. H. C. Plummer.

The determination of selenographic positions and the measurement of lunar photographs. Second paper: Determination of a first group of standard points from measures made at the telescope and on photographs. S. A. Saunder.

Ephemeris for physical observations of the Moon for 1902. A. C. D. Crommelin.

Note on two stars in the revised Madras Catalogue for 1835·0. A. M. W. Downing.

A new method of interpolation. T. C. Hudson.

On periodic orbits in the neighbourhood of centres of libration. H. C. Plummer.

The spectrum of Nova *Persei* from 1901 February 28 to April 26, with Appendix on the spectrum in September. Rev. W. Sidgreaves.

Ephemeris for physical observations of *Jupiter*, 1902–3. A. C. D. Crommelin.

On the variation of *T Centauri*. Alex. W. Roberts.

Comparison of the geocentric places of *Uranus*, *Neptune*, and the Sun, calculated from Newcomb's Tables, with their places calculated from Le Verrier's Tables, for the year 1904. A. M. W. Downing.

1901.

Nov. 8. Determination of Dr. Küstner's magnitude equation, from comparison of his meridian observations in zones $+24°$ to $+27°$ with measures of photographic plates taken at the University Observatory, Oxford. H. H. Turner.

On the place of the variable *RU Herculis* and neighbouring stars from photographic measures. F. A. Bellamy.

Experimental reduction of some photographs of *Eros* made at the Cambridge Observatory for the determination of the solar parallax. A. R. Hinks.

Further observations of the new star in *Perseus* made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Additional note on the green flash at sunset. W. H. Pickering.

Dec. 13. The observed motion and duration of the radiant point of the *Perseids*. W. F. Dunning.

Observations of Nova *Persei*. J. E. Gore.

Apparent paucity of the *Leonid* stream. Rev. S. J. Johnson.

Contribution to the history of the reflex zenith Tube. S. C. Chandler.

Note on a large fireball. W. F. Denning.

On the accuracy of measures on photographs : remarks on recent papers by M. Loewy and Mr. H. C. Plummer. A. R. Hinks.

On a simple method of accurate surveying with an ordinary camera. H. H. Turner.

The *Leonids*, 1901. Observations made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

The *Leonids*, 1901. F. W. Henkel.

Description of Adams's MSS. on the perturbations of *Uranus*. R. A. Sampson.

On the velocity of α *Persei*. H. F. Newall.

1902.

Jan. 10. Observation of the *Leonid* meteors of 1901 made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

The attraction of the Himalaya Mountains upon the plumb-line in India. Major S. G. Burrard.

Period and light curve of 6685 *Y Lyræ*. A. Stanley Williams.

Σ 1639 *Comæ Berenicis*. Thomas Lewis.

Observations of occultations of stars by the Moon and of phenomena of *Jupiter's* satellites made at the Royal Observatory, Greenwich, in the year 1901. Communicated by the Astronomer Royal.

1902.

Jan. 10. Observations of the satellite of *Neptune* from photographs taken at the Royal Observatory, Greenwich, in 1899–1900. Communicated by the Astronomer Royal.

On periodic orbits. E. T. Whittaker.

Comparison of photographic and visual magnitudes of the new star in *Perseus*. W. H. Robinson.

List of Public Institutions and of Persons who have contributed to the Library, &c., since the last Anniversary.

His Majesty's Government in India.
The Lords Commissioners of the Admiralty.
The French Government.
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British Horological Institute.
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Cambridge Philosophical Society.
Cardiff, Astronomical Society of Wales.
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Dublin, Royal Society.
Galway, Queen's College.
Leeds Astronomical Society.
Leeds Philosophical and Literary Society.
Liverpool Philosophical and Literary Society.
Liverpool Observatory.
Manchester Literary and Philosophical Society.
Oxford, Radcliffe Observatory.
Oxford, University Observatory.
Richmond (Surrey), National Physical Laboratory.
Rugby School Natural History Society.
Stonyhurst College Observatory.
Truro, Royal Institution of Cornwall.
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Batavia, Natural History Society of Netherlands-India.
Belgium, Royal Observatory.
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Berlin, German Physical Society.
Berlin, Institute of Computation of the Royal Observatory.
Berlin, Royal Observatory.
Berlin, Royal Prussian Academy of Sciences.
Berne University.
Bologna, Royal Academy of Sciences.
Bombay Branch of the Royal Asiatic Society.
Bombay, Government Observatory.
Bonn, Royal Observatory.
Bordeaux Observatory.
Bordeaux, Society of Physical and Natural Sciences.
Boston, American Academy of Arts and Sciences.
Breslau, Royal University Observatory.
Brisbane, Royal Geographical Society of Australasia.
Brussels, Royal Academy of Sciences of Belgium.
Buda-Pesth, Hungarian Academy of Sciences.
Buda-Pesth, Royal Hungarian Institute for Meteorology and Terrestrial Magnetism.
Calcutta, Asiatic Society of Bengal.
Canada, Department of Marine.
Canada, Geological Survey.
Canada, Royal Society.
Cape of Good Hope, Royal Observatory.
Cape Town, South African Philosophical Society.
Catania, Italian Spectroscopic Society.
Catania, Royal Observatory.
Connecticut, Academy of Arts and Sciences.
Copenhagen, Royal Danish Academy of Sciences.
Cracow, Academy of Sciences.
Dehra Dûn, Trigonometrical Survey of India.
Dijon, Academy of Sciences.
Egypt, Survey Department.
Geneva Observatory.
Geneva, Society of Physics and Natural History.
Georgetown College Observatory.
Göttingen, Royal Observatory.
Göttingen, Royal Society of Sciences.
Groningen, Astronomical Laboratory.

Halifax, Nova Scotian Institute of Sciences.
Halle, Imperial Leopold-Caroline Academy.
Hamburg Observatory.
Harvard College Astronomical Observatory.
Helsingfors, Society of Sciences of Finland.
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Kiel, Royal Observatory.
Kodaikanal Observatory.
Leiden Observatory.
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Leipzig, Prince Jablonowski Society.
Leipzig, Royal Society of Sciences of Saxony.
Lick Observatory.
Lund, Astronomical Observatory.
Madison, Washburn Observatory.
Madrid, Royal Academy of Sciences.
Manila Observatory.
Mauritius, Meteorological Society.
Mauritius, Royal Alfred Observatory.
Melbourne, Government Observatory.
Milan, Royal Observatory.
Moncalieri Observatory.
Moscow, Imperial Society of Naturalists.
Munich, Royal Bavarian Academy of Sciences.
Naples, Royal Academy of Sciences.
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Natal Observatory.
New York, Columbia University Observatory.
Nice Observatory.
Odessa Observatory.
O-Gyalla, Central Meteorological and Magnetical Observatory.
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Paris, Philomathic Society.
Pennsylvania, Sayre Observatory.
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Philadelphia, University of Pennsylvania.
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Pola, Meteorological and Magnetical Observatory.
Potsdam, Astrophysical Observatory.
Potsdam, Central International Geodetic Bureau.
Potsdam, Royal Prussian Geodetic Institute.
Poughkeepsie, Vassar College Observatory.
Prague, Imperial Observatory.
Prague, Royal Bohemian Academy of Sciences.
Pulkowa Observatory.
Rio de Janeiro Observatory.
Rome, Royal Academy *dei Lincei*.
St. Petersburg, Imperial Academy of Sciences.
San Fernando, Observatory of Marine.
San Francisco, Astronomical Society of the Pacific.
Stockholm, Royal Swedish Academy of Sciences.
Sydney, Royal Society of New South Wales.
Tacubaya, National Astronomical Observatory.
Tiflis, Physical Observatory.
Toronto, Astronomical Society.
Toronto, Canadian Institute.
Toulouse, Academy of Sciences.
Turin, Royal Academy of Sciences.
Turin, Royal Astronomical Observatory.
United States Coast and Geodetic Survey.
United States Department of Agriculture.
Upsala, Royal Society of Sciences.
Vienna, Imperial Academy of Sciences.
Vienna, Imperial Austrian Geodetic Bureau.
Vienna, Imperial Military Geographical Institute.
Virginia, Leander McCormick Observatory.
Washington, Office of the American Ephemeris.
Washington, Philosophical Society.
Washington, Smithsonian Institution.
Washington, United States Naval Observatory.
Yerkes Observatory.
Zürich, Central Meteorological Institute of Switzerland.
Zürich, Society of Natural History.
Editors of the "American Journal of Mathematics."
Editors of the "American Journal of Science."
Editor of the "Astronomical Journal."
Editor of the "Astronomische Nachrichten."
Editors of the "Astrophysical Journal."
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Editors of "Popular Astronomy."
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ADDRESS

Delivered by the President, Dr. J. W. L. Glaisher, on presenting the Gold Medal of the Society to Professor J. C. Kapteyn.

In awarding the Gold Medal of the Society to Professor J. C. Kapteyn for his work in connection with the Cape Photographic *Durchmusterung* and his researches on stellar distribution and parallax the Council have been able to place on record at the earliest opportunity their admiration of the noble services he has rendered to astronomy; and it is now my privilege to give a brief history of this great photographic catalogue and to refer to some of Kapteyn's other contributions to stellar cosmography.

In 1882 Gill tried the experiment of photographing the great comet of that year by means of a lens mounted in an ordinary camera, which was attached to the counterpoise of an equatorial. The successful results which he obtained suggested to him that with proper appliances photographic star maps could be constructed on any required scale and to any required order of magnitude.

During a visit to England in the early part of 1884 Gill obtained from Dallmeyer a rapid rectilinear lens of 6 inches aperture and 54 inches focus, this being the most suitable lens for astrophotographic work that Dallmeyer then had at his disposal. In September of the same year Gill applied for a grant from the Government Grant Fund of the Royal Society, partly for the purpose of photographing the solar corona and partly for making star maps by direct photography from the sky. With reference to the latter object he wrote: "I am most anxious to carry out this work for the southern heavens, being convinced that an accurate knowledge of star distribution according to magnitude can be more rapidly obtained in this way than in any other." The grant was made, and after some preliminary experiments systematic work was begun on April 10, 1885.

The first connection of Kapteyn with the work occurs eight months later. In a letter, written by him to Gill from Leyden on December 16, 1885, he made the following proposal: "If you will confide to me one or two of the negatives I will try my hand at them, and if the result proves as I expect, I would gladly devote some years of my life to this work, which would disburden you a little, as I hope, and by which I would gain the honour of associating my name with one of the grandest undertakings of our time." In a second letter, written a week later, after mentioning that at Groningen he is unprovided with an observatory, and sees no immediate prospect of obtaining one, he proceeds: "Now, after

your success in stellar photography, and especially after your letter in which you tell me, 'I am obliged to crave help where I can get it,' it has occurred to me that by measuring and reducing your photographs I could contribute very effectually towards the success of an enormous and eminently useful undertaking. Since then I have revolved the idea in my mind, and I have come to the conclusion that if you will let me, and if I can secure the necessary help, there is no one can be in better conditions to undertake the work than myself." In the concluding paragraph of the same letter, referring to the opinions of those he had consulted, he proceeds: "I am bound to say that they were not very enthusiastic about the matter; of course they thought the results once reached of immense value, but the drudgery to be gone through before these results are got into the form of a catalogue almost unbearable. However, I think my enthusiasm for the matter will be equal to (say) six or seven years of such work." As we shall see, Kapteyn did not overestimate his enthusiasm, which was to sustain him not only for six or seven years, but for nearly thirteen.

The actual photographing of the plates at the Cape, begun in April 1885, was continued without interruption until its completion at the end of 1890. There were several vicissitudes, principally relating to the lens. A second Dallmeyer lens of 6 inches aperture and 69 inches focus, which was expected to be superior to the first, was used for a time but found to be not so satisfactory. The portions of the sky, therefore, which had been photographed by it were rephotographed by the old lens, so that all the plates definitively used in the catalogue should be the work of the same lens.

The principal object which Gill had in view may be briefly described as the extension of the Bonn *Durchmusterung* to the south pole. To determine the exposure necessary for this purpose an area in the Bonn *Durchmusterung* was selected and photographed. The negative was then compared star by star with Argelander's chart, and the duration of the trial exposures was gradually increased till it was certain that every star in the selected part of the chart was shown as a measurable disc on the plate photographed from the sky. It may be mentioned that when the negative from the sky showed nearly the whole of Argelander's stars it also showed a great many more, as the Bonn *Durchmusterung* only professes to be complete as far as stars of the 9·2 magnitude.

Different kinds of plates were used during the five years over which the work extended. At first an exposure of an hour was required, but after about a year and a half more rapid plates were used, and the exposure was greatly reduced. At the time when the work was begun the difficulties were much greater than they would be now; the remarkable difference between the actinic and visual light of stars in different regions was unknown, as also was the variation of the sensibility of the plates due to moonlight

and other causes. Every area was photographed on two different nights in order to avoid the possibility of a speck on the plate being mistaken for a star.

I pass now to Kapteyn's work at Groningen : the measurements of the stars on the plates, their reductions, and the formation of the catalogue.

All the measurements for the catalogue were made by an instrument designed by Kapteyn for the purpose. The principle of this instrument, the object of which was to measure spherical coordinates directly from the plate, occurred to him very soon after he had received the first plates ; it depends upon the obvious fact that by placing a plate at the proper distance (that is, at the focal distance of the photographic telescope), with the film farthest from the eye, it is possible to cover the stars in the sky with their corresponding images. If, therefore, we substitute for the eye an instrument by which spherical coordinates can be measured in the sky, we can measure these coordinates as well on the plate as in the sky.

This instrument was employed in the early part of 1887 to measure the circumpolar plates (which were those first taken) to the tenth of a minute of arc, and it was found to be rapid and convenient in use and to give results of the accuracy required for a *Durchmusterung*. It was also shown that the stellar images were sufficiently sharp to be easily measurable to a second of arc, and a parallactic instrument capable of giving results to this degree of accuracy was devised by Kapteyn and Gill. It was, however, not constructed, and the whole of the measurements were made, to the tenth of a minute of arc, by the same instrument by which the circumpolar plates had been measured. In using this instrument Kapteyn always fixed two plates, corresponding to the same portion of the sky, in the plateholder, one in front of the other, at the distance of a millimetre. Small motions were provided, by means of which the corresponding star images of the two negatives could be brought nearly, but not quite, to superposition, so as to appear in the telescope like double stars, and thus true star images were at once distinguishable from accidental specks on the plates. Of these two plates, in case of the slightest difference, the one on which the images were more dense was employed to act as the check plate ; the other, mounted in front, was used as the measuring plate. The observations were made in a darkened room, the plates being illuminated from behind by a powerful lamp. The plates were square with a side of about six degrees.

In measuring the plates two observers always worked together one at the ocular, one at the microscope of the hour circle. A clerk wrote down all the numbers called out by the two observers in ledgers prepared for the purpose. The observer at the ocular estimated the diameter, read off the declinations on the scale, and made the pointings for right ascension. These were read off by the observer at the microscope. Three or four

hours in the morning and three hours in the evening were generally devoted to the observations.

Every plate was observed twice, the two observations being quite independent. As soon as the second observation of a plate was completed the two observations were compared and the discrepancies examined. The second observations and the examinations and revisions were invariably made by Kapteyn himself.

The diameters of the images of the stars were estimated to tenths of a minute of arc. This unit, however, being found too large in practice was subdivided into thirds. From these diameters the magnitudes of the stars were determined by an empirical formula involving two constants, which will be referred to later.

Great pains were taken that no speck on the plates should be treated as a star ; so careful indeed was Kapteyn in this matter that, as he states himself, many thousands of objects, by far the greater part of which are certainly true stars, have been lost to the catalogue. But it was his settled policy from the beginning not to introduce any object that was not a true star, and rather to lose ten real stars (of the very faintest class) than to incur the danger of introducing a single fictitious one.

Having now described in general terms the manner in which the plates were taken at the Cape, and observed and reduced at Groningen, I have to speak of certain special difficulties under which the work was carried out. As already mentioned a grant from the Government Grant Fund was made in 1885. The grant was repeated in 1886, but not in 1887. In that year the International Astrophotographic Congress had decided to undertake the work of forming a catalogue of stars to the 11th magnitude, and making charts of the heavens approximately to the 14th magnitude. It may have been thought by some that Gill's project was superseded by the decision of the Congress, but he himself never doubted the desirability of his own work, believing that in the existing state of astronomy its urgent need was increased rather than diminished by the results of the Congress. The completion of the work, however, without external assistance taxed even Gill's energy and resourcefulness to the utmost. Fortunately he persisted to the end ; but he was unable to have the parallactic instrument constructed that would have measured the plates to a second of arc, and he did not carry the work north of the declination $-18°$.

Kapteyn obtained some assistance from the Dutch Government and from several Dutch institutions, which enabled him to retain the services of two and sometimes three assistants. Only one, however, remained with him throughout ; the others, who were all at first quite inexperienced in work of the kind, frequently left after a short time, and these frequent changes added to the difficulties, and delayed the progress, of the work.

At length the catalogue was completed and published, forming three volumes of the Annals of the Cape Observatory. The

first volume bears the date 1896, the second 1897, the third 1900. The catalogue includes all stars down to about the 9·5 magnitude from −18° to the south pole. It has been mentioned that Gill's object was to extend Argelander's *Durchmusterung*, which was published in the middle of the last century, to the south pole, giving the magnitudes and approximate positions of the stars. Argelander's work, which included stars to the 9th or 10th magnitude, contained 324,188 stars; Schönfeld, who continued the catalogue from −2° to −23°, included 133,659 stars between these limits. The Cape *Durchmusterung* contains 454,875 stars between −18° and the south pole.

The catalogues of Argelander and Schönfeld contain 431,760 stars for the rest of the sky. The average number of stars for each square degree in the Cape, Argelander, and Schönfeld catalogues is 32·66, 15·19, and 18·21 respectively, so that the star density in the Cape catalogue is more than double as great as in Argelander's catalogue. The latter catalogue set a good example as regards freedom from errors, and there is every reason to believe that Kapteyn has fully maintained this high standard in the present volumes.

It is difficult to speak in too high terms of the zeal and ability displayed by Kapteyn during the years that he devoted to this catalogue. In the preface to the third and last volume Gill refers to him in the following terms: "It is my colleague and friend, whose name appears on the title page, to whom I am under the deepest obligation. At a time of great stress and discouragement he lifted from my shoulders a load of responsibility by his noble and spontaneous offer to undertake the measurement of the plates, the computation of the results, and the formation of the catalogue. He realised from the first the advantages and possibilities of the work, as well as the need for it in the present state of science, and he devoted over twelve of the best years of his life to the fulfilment of his undertaking. I now realise that my many other duties, and the difficulty of obtaining adequate assistance, would probably have compelled me to defer a great part of the work of the catalogue to the years of my retirement from official life, and might even have prevented its completion.

"I feel assured that Kapteyn has not laboured in vain, and that astronomers will duly appreciate what he has done for their science."

I may here also quote Newcomb's words: "This work of Kapteyn offers a remarkable example of the spirit which animates the born investigator of the heavens. . . . The years of toil devoted to it were, as the writer understands, expended without other compensation than the consciousness of making a noble contribution to knowledge, and the appreciation of his fellow astronomers of this and future generations." *

* *The Stars* (1901), p. 49.

Indeed we do appreciate his spirit and his work ; and we are delighted to have the means of expressing our appreciation as a Society to Kapteyn in person here to-day. Sustained by his enthusiasm for the value of the work, he did not shrink from carrying out himself the monotonous and anxious labour of making the measurements and comparisons, so that the catalogue has the great advantage of being the work of a single mind, incessantly devoted to securing the best results that the data could afford. If the enormous amount of work required by the measurements may, perhaps, be described—as it was by Kapteyn's friends at the outset—as drudgery, it was quite otherwise with the methods of procedure, many of the questions to be dealt with being novel and full of interest, as this was the first photographic catalogue. The most important of these questions related to magnitude, and it fell to Kapteyn to have to investigate in much detail the relation between photographic and visual magnitudes.

By comparing the variation of star-density as determined from the plates with the variation as determined by the visual observations of Schönfeld and Gould, he found that in some regions the plates contained three times the number of stars given by Schönfeld in the same area, while in other regions Schönfeld's catalogue was the richer, containing almost double the number of stars shown on the plates. He also found that, corresponding to these variations in the numbers of stars, there were similar variations in their brightness, equal diameters on the plates being produced by stars of very unequal brightness, in different parts of the sky. It is possible, as suggested by Thome, that the cause of these variations is purely observational, the visual observer not including so many very faint stars in the richer, as in the poorer, regions of the sky ; but Kapteyn considers any such explanation quite inadequate, and concludes definitely that the difference between the visual and photographic magnitudes is largely dependent upon the position of the stars relative to the Milky Way, and that, even when we take into account only stars of one and the same spectral type, those in the Milky Way are in general bluer than the stars in other regions of the sky.

The magnitudes were deduced from the diameters by the empirical formula $m = \frac{B}{d+C}$, d being the diameter of the image and B and C constants which were determined for each plate by comparing a number of stars with the magnitudes in Schönfeld's catalogue or in Gould's zone catalogue. This formula gives good results for stars between the magnitudes 6·5 and 9·5, but the uncertainty increases rapidly beyond these limits. The same formula has been used for the whole catalogue, the values of B and C being given for each plate, so that it will be easy to make the necessary corrections when a better formula is known or even to fall back, if need be, upon the quantities

really measured—that is, on the diameters of the stars on the plates.

With respect to the limits of magnitude to which the catalogue may be considered complete, Kapteyn concludes that the whole catalogue is complete to stars of the photographic magnitude 9·2, and that it will be found practically complete in or near the Milky Way to stars which in the scales of Gould, Schönfeld, and Thome are of the magnitude 9·5, and for the rest of the sky to stars actinically equivalent to these.

In the catalogue itself it is noted when a star is suspected of being double, or variable, or nebulous, and references are given to the principal catalogues in which a star has previously appeared. A characteristic feature of the work is the extremefulness of detail of the introductions, which, in addition to everything that can render the catalogue more serviceable, contain the results of extensive comparisons with catalogues of precision ; such, for example, as lists of stars of the magnitude 9·0, or brighter, not found in the plates. Since the publication of the catalogue Kapteyn has been occupied with the formation of lists of errors in the other catalogues, lists of stars with large proper motions, and of variables, as also with an examination of the colours of the stars in the Milky Way. These investigations are practically complete. I may mention that it was by such comparisons that the star with greatest known proper motion (8″·70) was discovered.

Thanks to the enthusiasm and perseverance of Gill and Kapteyn, we are now in possession of the Cape *Durchmusterung*. No doubt in the fulness of time it will be superseded by the astrographic chart of the heavens, which will not only include many more stars, but give their places with precision ; still it is a great matter that such a fund of information as the Cape catalogue supplies should have been rendered available at such a comparatively early date to the workers of our time. For the adequate treatment of the great cosmical problems relating to the magnitude and distribution of the stars, extreme accuracy of position is not required, and for all such investigations the Cape catalogue affords abundant material.

Before leaving the subject of the catalogue it should be mentioned that the whole of the measurements of the plates, and by far the greater part of the computations, were carried out in two rooms of the Physiological Laboratory at Groningen, which were kindly placed at Kapteyn's disposal by his colleague, Professor Huizinga. These two rooms constituted what was at that time a novel form of observatory—the possibility of which we owe to photography—in which the instrument was applied to the observation of the plates, instead of the stars themselves.

It is natural in this place to refer to an examination of the Cape *Durchmusterung* by Newcomb, who, after remarking that in the completeness with which it covers the field we have nothing equal to it in the northern hemisphere, expresses the

opinion that it can hardly be supposed that any object photographically brighter than the 9·5 magnitude has failed to be included. From a comparison with Thome's Cordoba catalogue he concludes that the limiting magnitudes of the different plates are in reality more nearly uniform than they were taken to be (in order to represent correctly both the brighter and fainter stars), and that it may be regarded as a fairly complete representation of the southern sky to a photographic magnitude of probably 10·0. This discussion of Newcomb's shows how greatly stellar research has been facilitated by the clearness and fulness with which the data of the catalogue have been presented.

At the time when Kapteyn made his proposal to Gill in 1885 he was occupied at Leyden with the determination of stellar parallaxes. His observations related to 45 stars, and he obtained 15 parallaxes, four of which had been previously determined by other observers. He employed a transit instrument and chronograph, and came to the conclusion that by his method he could obtain results comparable to those given by the heliometer. He suggested a plan for determining the parallaxes of all stars to the 5th magnitude. Each star was to be compared with two stars of the 8th magnitude. The whole scheme involved 16,640 complete observations, which he calculated could be carried out by two observers in eight years.

In 1889 Kapteyn proposed a much more comprehensive scheme—viz. that each plate for the astrographic catalogue should be exposed at three successive epochs of maximum parallactic displacement, being carefully preserved in the intervals of six months and developed after the third series of exposures. The plates would then furnish, in addition to the position of the stars, a first determination of their parallaxes. The proposal was not adopted for the catalogue work, but Professor Donner undertook to obtain with the astrographic equatorial at Helsingfors a series of plates for a definitive trial of this method of obtaining parallaxes *en bloc*. These plates Kapteyn measured at Groningen, and he obtained from them a first determination of the parallaxes of 246 stars. After giving a careful and detailed investigation of the results, he considers the possibility of a general *Durchmusterung* for parallax to include all stars down to the 10th magnitude, about 800,000 in number. This, he thinks, would secure about 500 well-determined parallaxes. Kapteyn's project breaks new ground and raises many questions; his own discussion, however, greatly narrows the issues for those who follow him upon these lines.

There is a great deal of other work connected with stellar parallaxes and proper motions upon which Kapteyn has been engaged, much of which still remains unpublished. As the direct determination of stellar parallax has not as yet given results on anything like the scale required for the purpose of judging of the relative distances of the stars, we are compelled to resort to the parallactic displacement caused by the motion of the solar

system in space. This parallactic motion, however, cannot be separated from the real proper motion for individual stars, but there is every reason to think that the real proper motion shows very little preference for determinate directions, and it may therefore be assumed that, in the mean results obtained from small groups of stars, these real proper motions will destroy each other, leaving only that part which is due to solar motion, and it is this parallactic displacement that gives the most reliable measure of the mean distance of the stars under consideration.

If we transform the proper motions from right ascension and declination to motions in the apical direction (*i.e.* along the great circle joining the star to the solar apex) and perpendicular to it, it is clear that the former is affected by the parallactic motion, but that the cross motion, perpendicular to the apical direction, gives the true component of the motion of the star. Led by these considerations Kapteyn undertook the labour of resolving in the apical direction and perpendicular to it the proper motions of the 2357 stars in Draper's catalogue of spectra, which are also included in the Bradley-Auwers catalogue, and were observed both in right ascension and declination. The stars were taken from Draper's catalogue because Kapteyn had decided to divide them into groups according to their spectral type, and to consider the groups separately. This division has shown that stars with small proper motions belong generally to the first type, and those with large proper motion to the second. It may be that the stars of the second type are moving faster than those of the first, but it seems more probable that they are less distant. This gives some support to Gould's suggestion that the Sun is a member of a star cluster.

I must necessarily pass over other important papers of Kapteyn's upon the distribution of cosmical velocities, the distribution of stars in space, the statistical relations between parallax, proper motion, and magnitude, and upon the luminosity of the stars. As a detail in his larger statistical researches he has deduced the position of the solar apex by a new method (Kapteyn's method), in which the apex is so chosen that the sum of the proper motions resolved in the direction of the anti-apex is a maximum, or that the sum of the motions perpendicular to this direction is zero. The resulting apex is $\alpha = 273°{\cdot}6$, $\delta = 29°{\cdot}5$ as deduced from 2640 Bradley stars and 699 Porter stars. The discrepancy from Porter's result (obtained by Kapteyn's method), $\alpha = 280°{\cdot}5$, $\delta = 49°{\cdot}3$, and from Campbell's result $\alpha = 277°{\cdot}5$, $\delta = 20°{\cdot}0$, derived from spectroscopic determinations of velocity in the line of sight (280 stars), only shows, what might have been expected, that considerable groups of stars in different parts of the sky are affected by common drift, which is quite distinct from parallactic motion.

I need not do more than merely refer to Kapteyn's simple and ingenious suggestion in explanation of the phenomena of Nova *Persei*, which has been discussed so recently, and with so much interest, in this room.

It will have been seen that one spirit runs through all Kapteyn's work, viz. an effort to treat the great cosmical problems comprehensively, and to apply to them general methods which, though not exact, may be expected to give information which would be quite unattainable by any procedure resting upon an absolutely sure foundation with respect to every individual star. Always occupied with the most effective means of attacking the great problems of the universe, he has never flinched from the heavy labour required to carry his ideas into practice ; and it is very fitting that one whose mind has been from the first so much attracted by the more difficult questions presented by the statistics of the heavens should himself have contributed such invaluable material for the study of the subject which he has so much at heart.

The President then, delivering the medal to Professor Kapteyn, addressed him in the following terms :—

Professor Kapteyn, in placing in your hands this Gold Medal I wish specially to congratulate you upon the completion of the Cape *Durchmusterung*, and to express to you the hope that your life may long be spared, and that you may have health and strength to extract from this grand storehouse of your own formation many more of the great cosmical truths which it implicitly contains, and to enrich still further by your labours the important branch of our science to which you have devoted your life.

In handing to Dr. T. D. Anderson the Jackson-Gwilt medal the President addressed him as follows :—

Dr. Anderson, it is a great pleasure to me to hand you on behalf of the Society the Jackson-Gwilt medal in recognition of your discovery of both Nova *Aurigæ* and Nova *Persei*. Nova *Aurigæ* was discovered by you on February 1, 1892, when of the 4th magnitude, and but for your discovery it might have escaped observation. Nova *Persei* was discovered on February 22 of last year at 2.40 A.M., when of the 2·7 magnitude and low down in the sky. This early discovery of yours made it possible for Pickering to obtain its spectrum before its maximum was reached.

It is no small matter to have discovered one of these Novæ, but it is a veritable *tour de force*, such as *à priori* would have seemed almost incredible, to have discovered both, and I am delighted that we have the opportunity to congratulate you on your success and do honour to your astronomical zeal and intimate knowledge of the sky. Between your two discoveries several new stars had been found at Harvard, but all by photography.

I ought, perhaps, to refer at greater length to the number of variable stars—no less than thirty-eight—that you have discovered ; but on the present occasion I should prefer to restrict myself to the subject of the award, your wonderful discoveries of the two great Novæ of our time.

The meeting then proceeded to the election of Officers and Council for the ensuing year, when the following Fellows were elected :—

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